Collaborative for High Performance Schools

Massachusetts High Performance Green Schools Guidelines:

Criteria

Version 1.0

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A PROJECT OF:

the collaborative for high performance schools

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Preface

THE GUIDELINES IN BRIEF

The Massachusetts High Performance Green Schools Guidelines are based on California's Collaborative for High Performance Schools (CHPS) guidelines but are tailored specifically for Massachusetts code requirements, the New England climate, and the environmental priorities of the region.

CHPS

NEW BUILDINGS INSTITUTE

UNITED STATES GREEN BUILDING COUNCIL (USGBC)

Through its Leadership in Energy and Environmental Design (LEED) guidelines for new construction, the United States Green Building Council (USGBC) has provided the infrastructure and invaluable research to make development of the Guidelines possible. In many instances we have included LEED guidelines because they are state-of-the-art, because they are the most widely known and applied in the U.S., and because the USGBC provides many resources, including its reference guides, to support the design and construction of green buildings. We appreciate the national and international efforts of the USGBC to promote green building design and practices.

Acknowledgements

Creation of this groundbreaking document for schools could not have been realized without the help of an outstanding group of green building experts and policymakers from both the public and private sectors. Many hours of volunteer work went into making the Massachusetts High Performance Green Schools Guidelines and for every minute, we are grateful. Thank you for your help.

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Introduction

The Commonwealth of Massachusetts recognizes the increasing demands on financial and natural resources to support the renovation and construction of its public schools. Therefore, the Commonwealth has embarked on a program to encourage the design and construction of schools known as "high performance green schools" to ease the energy, water, materials, and financial burden of building educational facilities for pre-K–12 students.

WHAT IS A HIGH PERFORMANCE GREEN SCHOOL?

A high performance green school has three distinct attributes: it is less costly to operate than a conventional school; it is designed to enhance the learning and working environment; and it conserves important resources such as energy and water.

A high performance green school is designed to optimize the durability of the facility and to utilize high efficiency, "right sized" heating, ventilating, and air conditioning equipment and lighting systems. Where possible, glare-free daylight is brought into the school to enhance the learning environment. The building shell integrates the most effective combination of insulation, glazing, and thermal mass to ensure energy efficiency, and plumbing fixtures are specified to reduce water consumption. Together, these measures significantly reduce the operational costs of running the school building. It is reasonable to assume a 20%-40% cost savings in utility bills versus a non-green building of the same size and shape.

A high performance green school is thermally, visually, and acoustically comfortable. Thermal comfort means that teachers, students and administrators should neither be hot nor cold as they teach and learn. Visual comfort means that the quality of lighting makes visual tasks, such as reading and following classroom presentations, easier. Acoustic comfort is achieved when students and teachers can hear each other and are not impeded by loud ventilation systems or noise from adjoining spaces.

High quality indoor air is another important feature of a green school. Air intakes are located away from potential sources of contamination and ventilation systems are designed to optimize fresh air. Architects and engineers incorporate best design practices to prevent water intrusion into wall and roof assemblies. This, in turn, prevents the accumulation of moisture in materials that could support mold growth or lead to premature replacement of indoor finishes and even structural elements.

A high performance green school has an environmentally responsive site**.** To the extent possible, the school's site conserves existing natural areas and incorporates them into the curriculum. Stormwater runoff is minimized and/or captured on site for irrigation or flushing water closets. The site is accessible to bicycle and pedestrian traffic and is conveniently located for community activities.

While operational savings, environmental stewardship, and community-building are attractive benefits, it is important to emphasize that, above all, a high performance green school provides an environment that enhances the primary mission of public schools: education of future citizens.

MASSACHUSETTS HIGH PERFORMANCE GREEN SCHOOLS GUIDELINES

The Guidelines are provided as a benchmark for green school buildings. This document is divided into six sections: site, water, energy, materials, indoor environmental quality (IEQ), and policy and operations. Each section has prerequisites that must be achieved, but the rest of the guidelines are optional credits.

SCORING

The Massachusetts School Building Authority is authorized to grant an additional 2% reimbursement incentive for a public school construction project that achieves certain point thresholds in the Massachusetts High Performance Green School Guidelines. Project scores will be verified by a third party certifier. To receive a 1.5% reimbursement incentive, projects must achieve 30 points. To receive the full 2.0% reimbursement incentive, projects must achieve 34 points.

APPLICATION TEMPLATE

A separate document called the "Application Template" provides a series of Excel spreadsheets with which to submit documentation for each prerequisite and credit that is attempted. Use the Application Template to submit documentation for certification as a high performance green school.

AUDIT REQUIREMENTS

In Massachusetts, the application for certification of a green school is typically made as construction drawings and bid specifications are nearing completion. Because significant changes can be made to projects during the construction phase, audits will be conducted to ensure that every prerequisite and point that was claimed was actually achieved by year one of occupancy of the completed school. Please make a note of audit requirements and set aside documentation to provide when the school is audited.

CRITERIA OVERVIEW

Category	Category	Credit Name	
Site	Site Selection	Prereq 1	Joint Use of Facilities
		Prereq 2	Joint Use of Parks
	Sustainable Sites	Credit 1.1	Sustainable Site Selection
		Credit 1.2	No Development on Flood Plains
		Credit 1.3	No Development Near Wetlands
		Credit 1.4	No Development on Greenfields
		Credit 1.5	Centrally Located Sites/Smart Growth
		Credit 1.6	Reduced Building Footprint
		Credit 1.7	Sustainable Site & Building Layout
	Transportation	Credit 2.1	Locate Near Public Transit
		Credit 2.2	Pedestrian/Bike Access
		Credit 2.3	Minimize Parking
	Stormwater Management	Credit 3	Post-Construction Stormwater Management
	Outdoor Surfaces	Credit 4.1	Design to Reduce Heat Islands, Non-roof
		Credit 4.2	Design to Reduce Heat Islands, Roof
	Outdoor Lighting	Credit 5	Exterior Light Pollution Reduction
Water	Indoor Systems	Prereq 1	Indoor Water Use Reduction - 20%
		Credit 1.1	Indoor Water Use Reduction - 30%
		Credit 1.2	Reduce Water Used for Sewage Conveyance
	Outdoor Systems	Credit 2.1	No Permanent Irrigation for Landscaping
		Credit 2.2	Water Reduction and Sports Turf Management
		Credit 2.3	Irrigation System Commissioning
Energy	Environmental Impacts	Prereq 1	Elimination of CFC-Based Refrigerants
	Commissioning and Training	Prereq 2	Commissioning
		Prereq 3	Fundamental Building Systems Training Commissioning
	Energy Efficiency	Prereq 4	Exceed Code by 20%, Prescriptive Approach –OR- Exceed Code by 20%, Performance Approach
		Credit 1	Superior Energy Performance, Prescriptive –OR- Superior Energy Performance, Performance
		Credit 1.2	Minimize Air Conditioning

Category	Category	Credit Name	
	Alternative Energy Sources	Credit 3	Renewable Energy
	Energy Tracking	Credit 4.1	Energy Management Systems
		Credit 4.2	Submetering
Materials	Waste Reduction & Efficient Material Use	Prereq 1	Storage & Collection of Recyclables
		Prereq 2	Site Waste Management - 75%
		Credit 1	Site Waste Management - 90%
	Building Reuse	Credit 2.1	Building Reuse 50% - 95%
		Credit 2.2	Building Reuse Interior, 50%
	Sustainable Materials	Credit 3	Combined Materials Attributes
IEQ	Indoor Air Quality Prereqs	Prereq 1	ASHRAE *Standard 62.1-2004* Compliance
		Prereq 2	SMACNA IAQ Guidelines
		Prereq 3	Construction IAQ, Duct Protection
		Prereq 4	Pollutant Source Control, Off-Gassing
		Prereq 5	Walk-Off Mats
		Prereq 6	Drainage
		Prereq 7	Irrigation Design
		Prereq 8	Mold Protection
		Prereq 9	Electric Ignition for Gas Fired Equipment
		Prereq 10	Air Intake Location
		Prereq 11	Duct Liners
		Prereq 12	Prohibit Fossil-Fuel-Burning Equipment Indoors
		Prereq 13	Minimum Filter Requirements for HVAC Equipment
	Thermal Comfort Prereq	Prereq 14	ASHRAE *Standard 55-2004* Compliance
	Daylighting & Views	Prereq 15	Access to Views, 70%
		Credit 1.1	Access to Views, 90%
		Credit 1.2	Daylighting in Classrooms
	Indoor Air Quality Credits	Credit 2.1	Low-Emitting Materials
		Credit 2.2	Pollutant Source Control, Ducted HVAC Returns
		Credit 2.3	Pollutant Source Control, High Efficiency Filters
		Credit 2.4	Construction IAQ, HEPA Vacuuming
		Credit 2.5	Construction IAQ, Building Flushout
	Acoustics	Credit 3.1	Minimum Acoustical Performance
		Credit 3.2	Improved Acoustical Performance, 35 NC
		Credit 3.3	Improved Acoustical Performance, 30 NC

Category	Category	Credit Name	
		Credit 3.4	Noise Pollution Reduction
	Thermal Comfort Credit	Credit 4.1	Controllability of Systems, Windows
		Credit 4.2	Controllability of Systems, Temp./Light
Policy & Operations	Project Level	Prereq 1	Maintenance Plan
		Prereq 2	Anti-Idling Measures
		Credit 1	Computerized Maintenance Management System
		Credit 2	Indoor Environmental Management Plan
		Credit 3	ENERGY STAR Equipment Performance
		Credit 4.1	Clean Energy, 50%
		Credit 4.2	Clean Energy, 100%
		Credit 5	Innovation

CRITERIA SCORESHEET

The following table is a worksheet for totaling your points. There is an Excel version of the scoresheet in the Application Template.

MA-CHPS SCORECARD

This matrix includes each point that is available. Please fill in the credits you are applying for with a numerical value for a **Total Project Score**.

0	Total Project Score	Total Possible Points 89

0	Points		SITE	Possible Points 16
	---	SP 1	**Joint Use of Facilities**	
	---	SP 2	**Joint Use of Parks**	
	1	SC 1.1	**Sustainable Site Selection**	
	1	SC 1.2	**No Development on Floodplains**	
	1	SC 1.3	**No Development Near Wetlands**	
	1-2	SC 1.4	**No Development on Greenfields**	
	1	SC 1.5	**Centrally Located Site/Smart Growth**	
	1	SC 1.6	**Reduced Building Footprint**	
	1	SC 1.7	**Sustainable Site and Building Layout**	
	1	SC 2.1	**Locate Near Public Transit**	
	1	SC 2.2	**Pedestrian/Bike Access**	
	1	SC 2.3	**Minimize Parking**	
	1	SC 3	**Post-Construction Stormwater Management**	
	1	SC 4.1	**Design to Reduce Heat Islands,** Non-Roof	
	1	SC 4.2	**Design to Reduce Heat Islands,** Roof	
	2	SC 5	**Exterior Light Pollution Reduction**	

0	Points		WATER	Possible Points 5
	---	WP 1	**Indoor Water Use Reduction,** 20% Reduction	
	1	WC 1.1	**Indoor Water Use Reduction,** 30% Reduction	
	1	WC 1.2	**Reduce Water Used for Sewage Conveyance**	
	1	WC 2.1	**No Permanent Irrigation For Landscaping**	
	1	WC 2.2	**Water Reduction and Sports Turf Management**	
	1	WC 2.3	**Irrigation System Commissioning**	

0	Points		ENERGY	Possible Points 25
	---	EP 1	**Elimination of CFC-based Refrigerants**	
	---	EP 2	**Commissioning**	
	---	EP 3	**Fundamental Building Systems,** Training	
	---	EP 4	**Exceed Energy Code by 20%,** Prescriptive Approach	
	---	EP 4	**Exceed Energy Code by 20%,** Performance Approach	
	1-2	EC 1	**Superior Energy Performance,** Prescriptive Approach	
	1-10	EC 1	**Superior Energy Performance,** Performance Approach	
	2	EC 2	**Minimize Air Conditioning**	
	2-11	EC 3	**Renewable Energy**	
	1	EC 4.1	**Energy Management Systems**	
	1	EC 4.2	**Submetering**	

0	Points		MATERIALS	Possible Points 13
	---	MP 1	**Storage & Collection of Recyclables**	
	---	MP 2	**Site Waste Management,** 75% Diversion	
	1	MC 1	**Site Waste Management,** 90% Diversion	
	1-4	MC 2.1	**Building Reuse,** Maintain 50-95% of Existing Shell	
	1	MC 2.2	**Building Reuse,** Interior 50%	
	1-7	MC 3	**Combined Materials Attributes**	

0	Points		IEQ	Possible Points 22
	---	IEQP 1	**ASHRAE Standard 62.1-2004 Compliance**	
	---	IEQP 2	**SMACNA IAQ Guidelines**	
	---	IEQP 3	**Construction IAQ,** Duct Protection	
	---	IEQP 4	**Pollutant Source Control,** Off-gassing	
	---	IEQP 5	**Walk-Off Mats**	
	---	IEQP 6	**Drainage**	
	---	IEQP 7	**Irrigation Design**	
	---	IEQP 8	**Mold Protection**	
	---	IEQP 9	**Electric Ignitions - Gas-Fired Equipment**	
	---	IEQP 10	**Air Intake Location**	
	---	IEQP 11	**Duct Liners**	
	---	IEQP 12	**Prohibit Fossil Fuel Burning Equipment,** Indoors	
	---	IEQP 13	**Filter Requirements for HVAC Equipment**	
	---	IEQP 14	**ASHRAE Standard 55-2004 Compliance**	
	---	IEQP 15	**Access to Views,** 70%	
	2	IEQC 1.1	**Access to Views,** 90%	
	1-4	IEQC 1.2	**Daylighting in Classrooms**	
	1-4	IEQC 2.1	**Low-Emitting Materials**	
	1	IEQC 2.2	**Pollutant Source Control,** Ducted HVAC Returns	
	1	IEQC 2.3	**Pollutant Source Control,** High Efficiency Filters	
	1	IEQC 2.4	**Construction IAQ,** HEPA Vacuuming	
	2	IEQC 2.5	**Construction IAQ,** Building Flushout	
	1	IEQC 3.1	**Acoustical Performance in Classrooms,** Max 40 NC	
	1	IEQC 3.2	**Acoustical Performance in Classrooms,** Max 35 NC	
	2	IEQC 3.3	**Acoustical Performance in Classrooms,** Max 30 NC	
	1	IEQC 3.4	**Reducing Sound Transmission**	
	1	IEQC 4.1	**Controllability of Systems,** Operable Windows	
	1	IEQC 4.2	**Controllability of Systems,** Temperature/Light Control	

0	Points		POLICY & OPERATIONS	Possible Points 8
	---	P&OP 1	**Maintenance Plan**	
	---	P&OP 2	**Anti-Idling Measures**	
	1	P&OC 1	**Maintenance Plan,** CMMS	
	1	P&OC 2	**Indoor Environmental Management Plan**	
	1	P&OC 3	**Energy Star Equipment Performance**	
	1	P&OC 4.1	**Clean Energy,** 50%	
	1	P&OC 4.2	**Clean Energy,** 100%	
	1-3	P&OC 5	**Innovation**	

Requirement for all schools
Requirement for green schools only

Point Thresholds
30 points - 1.5% Financing of Maximum Allowable Project Cost
34 points - 2.0% Financing of Maximum Allowable Project Cost

Site

SITE SELECTION

Purpose: To choose sites that protect students and staff from outdoor pollution and minimally impact the environment, as well as to channel development to centrally located areas, with existing infrastructure, to protect greenfields, minimize transportation requirements, and preserve habitat and natural resources.

PREREQUISITE 1: JOINT USE OF FACILITIES

Required for Green Schools	SP 1. Ensure that the building itself (e.g., layout, special design features) facilitates the school's use by the community or other appropriate organizations.

The most successful schools have a high level of parent and community involvement. This involvement can be enhanced if a school is designed so that neighborhood meetings, recreation activities, and other community functions can take place at the school in a safe and secure fashion.

Building or renovating a school provides an opportunity for the community to incorporate municipal programs and services into the building program. During the planning stages, school districts should give careful thought to the types of programs, services, and facilities they may wish to offer via the future school building (e.g., library services, recreation services, meeting space, space for special events, etc.).

Other strategies that contribute to shared use of the school building include designing separate entrances for spaces likely to be shared, adjusting building orientation and layout to separate classroom and administration areas from shared spaces during events, and designing special features into the school that the community can use.

It is important to remember that the relatively low cost strategies mentioned above satisfy this prerequisite. Additional features, such as the walking track pictured here, are encouraged only if the community has the resources to pay for and maintain these facilities.

Whitman-Hanson Regional High School. An elevated walking track surrounds the gymnasium. Local residents will be able to use it any time throughout the day.

Documentation
Letter signed by project architect and school superintendent indicating features of the school that enhance its shared use with the community.

Audit Requirements
None.

PREREQUISITE 2: JOINT USE OF PARKS

Required for Green Schools	SP 2. Share park or recreation space with local park boards or other organizations.

Joint use of recreational space is a growing trend across the country. This prerequisite is intended to encourage schools to share their recreational space with the community at large or vice versa –to encourage municipalities to allow schools to use local parks in lieu of having the school construct playing fields. Either arrangement allows the community to optimize resources dedicated to community and school recreation.

Documentation
A copy of the formal agreement between the school district and municipality on joint use of parks and recreational space OR provide copies of applicable insurance policies governing use of the parks or recreational space by the municipality or by the school if the spaces are municipally owned.

Audit Requirements
None.

Michael E. Capuano Early Childhood Center—Somerville. A community garden was incorporated into the school project and is now available for use by local citizens. Photo credit: HMFH Architects, Inc.

SUSTAINABLE SITES

Purpose: Protect environmentally sensitive site features, such as wetlands and tree stands, and encourage landscaping and architecture that responds to and includes the school's immediate environment.

CREDIT 1.1: SUSTAINABLE SITE SELECTION

1 point	SC 1.1. Do not temporarily or permanently modify land, which prior to acquisition for the project was public parkland, conservation land, or land acquired for water supply protection.

A district faces many issues during site selection. Cost, student demographics, and environmental concerns all influence site acquisition. The site is a crucial element in determining the overall sustainability of the school design. Some sites are purchased years in advance, which leaves little room for input from the districts and designers. However, districts that are considering multiple sites can substantially lower the environmental impact of the school by choosing centrally located sites, sharing parks or facilities with community organizations, preserving open space, and protecting environmentally sensitive areas.

Documentation

Provide a current existing site survey with the school site property boundaries marked in bold.

Audit Requirements

None.

CREDIT 1.2: NO DEVELOPMENT ON FLOOD PLAINS

1 point	SC 1.2. Do not develop buildings on land whose elevation is lower than the elevation of the 100-year flood as defined by FEMA and as shown on the FEMA Flood Insurance Rate Map (FIRM) for the site.

Do not construct permanent buildings, or structures to support buildings within the 100-year flood plain. Both federal and state agencies have worked together over the last several decades to prevent construction of buildings in 100-year floodplains to achieve two important results: 1) a significant decrease in building damage and liability and 2) a restoration of functional floodplains to absorb flood waters and minimize impacts to downstream communities.

"Above the floodplain" means that the building footprint must be above the 100-year flood plain, but the requirement does not apply to non-building areas of the site. In Massachusetts, floodplains are defined as Wetland Resource Areas; therefore, if the school project develops athletic fields, parking lots and other structures in the 100-year floodplain, then the project is prohibited from receiving Wetlands Site Credit 1.3, as these areas would constitute wetlands under the law.

To locate the 100-year floodplain elevations in Massachusetts, FEMA Flood Insurance Studies (containing Flood and Coastal Profiles) and flood maps are available on the web at www.msc.fema.gov/. For locations not mapped by FEMA, consult the Massachusetts Wetland regulations, available on the web at: http://www.mass.gov/dep/water/laws/regulati.htm#wl specifically 310 CMR 10.57 which describes the process to follow in determining the floodplain elevation in the absence of FEMA information. It is also recommended that you consult with your municipal conservation commission, which regulates construction in floodplains pursuant to the Wetlands Protection Act. The conservation commission may be able to

provide useful information regarding flood prone locations in the municipality as well as may have copies of the FEMA Flood Insurance Studies and Maps on file.

In Massachusetts, construction within the 100-year floodplain is subject to regulation pursuant to the Massachusetts wetlands protection regulations, 310 CMR 10.02, and State Building Code, 780 CMR 3107. The Massachusetts Department of Conservation and Recreation (DCR) Office of Water Resources, Flood Hazard Management Program can provide assistance to municipalities regarding floodplain regulations. The contact telephone number is 617-626-1406, or visit the web at www.mass.gov/dem/programs/mitigate.

Documentation

FIRM Map, highlight 100-yr flood plain area OR provide map from FEMA Web site with 100-yr flood plain highlighted. Clearly indicate the building footprint on the map showing that it will not be in the 100-year flood plain.

Audit Requirements

None.

CREDIT 1.3: NO DEVELOPMENT NEAR WETLANDS

1 point	SC 1.3. Do not develop school sites that are within wetland resource areas as defined by Massachusetts Wetlands Protection Act, M.G.L. Chapter 131 Section 40 or within 50 feet of banks, vegetated wetlands, or vernal pools. Site development includes the school facilities, playing fields and parking lots and construction operations that are not related to wetlands improvement. Please see: http://www.mass.gov/dep/water/laws/ilsf.htm for wetland definitions. *Exception:* Drainage outfall structures may be located within the 50 ft. buffer zone provided they meet setback criteria specified in Volume II of the Massachusetts Department of Environmental Protection's Stormwater Management Policy.

Do not build on sites, which are within 50 ft. of a wetland as defined below. Site development includes the school facilities, playing fields and parking lots and construction operations that are not related to wetlands improvement. Drainage outfall structures may be located within the 50 ft. buffer zone provided they meet setback criteria specified in Volume II of the Massachusetts Department of Environmental Protection's Stormwater Management Policy.

The Massachusetts Wetlands Protection Act, MGL Chapter 131 Section 40 lists each specific wetland type subject to protection, including, but not limited to, swamps, marshes, bogs, salt marshes, lakes, ponds, rivers, riverfront areas, and land subject to flooding. Alterations to coastal and inland wetland resource areas, including any associated buffer zones, are regulated pursuant to the Massachusetts Wetlands Protection Act (WPA) and Water Quality Certification regulations. Local conservation commissions administer WPA regulations.

The Wetlands Protection Act and 401 Water Quality Certification regulations for discharge of dredged or fill material may be found on the web at the following address: http://www.mass.gov/legis/laws/mgl/131-40.htm.

Documentation

1. NPDES Notice of Intent for coverage under the NPDES General Permit and Wetlands Order of Conditions (if applicable).
2. As-designed site plan showing the 50-foot zone around wetlands on the site. Mark school site property boundaries in bold and clearly delineate the building footprint, playing fields, parking

lots, and area of construction operations (such as cut and fill areas and staging areas) on the site plan.

Audit Requirements
None.

CREDIT 1.4: NO DEVELOPMENT ON GREENFIELDS

1 – 2 points	SC 1.4. Do not build on greenfields. For the purposes of this credit, greenfields are defined as undeveloped lands or lands that are used for agriculture, forestry, or park purposes. Undeveloped lands are defined as lands that have not been in use for a period of 50 years or more and cannot be identified, by visual inspection, as having been developed. • New School Projects – 1 point • Addition /Renovation and Renovation Projects –2 points

During the site selection process, use previously developed sites instead of greenfields. Redevelopment reduces environmental impacts by utilizing established infrastructure and preserving the open space of undeveloped lands.

Documentation
To determine whether there have been significant developments on a site prior to its designation as a school construction site, submit a summary of a Phase I Initial Site Investigation report prepared according to Massachusetts Contingency Plan regulations (310 CMR 40.00). The Massachusetts Contingency Plan regulations were created for the prevention and control of activities leading to the release of oil and/or hazardous material, and they include provisions for researching historical site activities. The summary should describe any previous uses of the school site as far back as a reasonable search of local fire department records, records of incorporation, Registry of Deeds etc. can be achieved. Provide a copy of the Massachusetts Environmental Policy Act (MEPA) Office's Environmental Notification Form (ENF) showing that the site is not in use for agricultural or forestry purposes and is not in use as a park.

Audit Requirements
None.

CREDIT 1.5: CENTRALLY LOCATED SITES/SMART GROWTH

1 point	SC 1.5. Construct or renovate a school according one of the following criteria: Site the school at least ½ mile of at least 8 of the basic services listed: 1) Supermarket; 2) Commercial Office Building; 3) Convenience Grocery; 4) Day Care; 5) Cleaners; 6) Fitness center; 7) Hair Care; 8) Hardware; 9) Laundry 10) Library; 11) Medical/Dental Services; 12) Senior Care Facility 13) Public Park; 14) Pharmacy; 15) Post Office; 16) Bank; 17) Community Center (e.g., recreation center, after-school program building, or art center). OR Verify that your municipality has a current and accepted Commonwealth Capital Application with the Office for Commonwealth Development. If applying MA-CHPS guidelines as a regional school district, then verify that at least half of the municipalities in the regional school district have current and accepted applications.

Siting schools in areas of density and/or mixed use allows more students to walk or bike to school, while reducing the distance cars must travel. Schools located near public and private services such as libraries and community centers not only allow students to access these services after school, they put parents en route to these services if they pick their children up after school (though use of public transportation is strongly encouraged). Planning around centers of public and private activity is embodied in the concept of Smart Growth, which promotes dense development in order to preserve public parks and natural features such as open space and wildlife habitat.

Each year, many municipalities apply to the Massachusetts' Office for Commonwealth Development to the Commonwealth Capital program. Communities receive points on their applications for zoning, planning, natural resources protection etc. that weave together initiatives that embody the concept of "smart growth". To learn more information about the program, visit the Office for Commonwealth Development's website at www.mass.gov/commcap.

Documentation

Provide a map showing the ½ mile perimeter around the school and indicating the names and location of eight of the basic services listed in the credit text box. The ½ mile radius may be drawn from EITHER the front entrance of the school, where the school driveway meets the public way, or from the front door of the school. The front door of the basic service identified on the map must fall within the ½ mile radius. Online tools such as MapQuest™ may also be submitted as documentation of the ½ mile radius.

OR

Provide a copy of your municipality's Commonwealth Capital Application current score as furnished by the Office for Commonwealth Development.

Audit Requirements

None.

Resources

Office for Commonwealth Development, see website: www.mass.gov/commcap

CREDIT 1.6: REDUCED BUILDING FOOTPRINT

1 point	SC 1.6. Increase the Floor Area Ratio (FAR) of the school to be at least 1.4 to reduce the development footprint and preserve open space. In this document, the FAR is defined as building's gross square footage divided by the square footage of the building footprint.

Building multi-story schools reduces the amount of land used in construction. Said another way, achieving a FAR of 1.4 requires at least 40% of the total building square footage needs to be above the first floor.

Documentation

Calculate the Floor Area Ratio (FAR) by dividing the school facility's footprint by the facility's entire square footage including all stories. See Application Template to input your project's data.

Audit Requirements

None.

CREDIT 1.7: SUSTAINABLE SITE & BUILDING LAYOUT

1 point	SC 1.7. Sustainable Site and Building Layout. Implement four of the following best practice site strategies: 1. Orient the building(s) to take advantage of maximum natural daylighting OR plot shadow patterns from surrounding buildings and place buildings to optimize access to daylight (for urban-infill sites). 2. Consider prevailing winds when determining the site and building layout. For example, consider how the shape of the building itself can create wind-sheltered spaces and consider prevailing winds when designing parking lots and driveways to help blow exhaust fumes away from the school. 3. Take advantage of existing land formations and vegetation to provide shelter from extreme weather or to deflect unwanted noise. 4. Plant or protect existing deciduous trees to block summer sun and allow winter solar gain. Plant or protect existing coniferous trees to block winter wind. Planting should be done an adequate distance from the building to prevent the accumulation of water along the building envelope. 5. Minimize importation of non-native soils and exportation of native soils. Optimize Cut & Fill (ideally in 1:1 proportions) during clearing and excavation. 6. Create physical connections to bike paths, natural features, or adjacent buildings. 7. Site the building to maximize opportunities for on-site renewable energy generation. For example, preserve or ensure availability of space for wood chip storage facilities for biomass heating, wind turbines, or other renewable energy sources.

Performing a thorough site analysis at the pre-design phase is critical to understanding all the opportunities and complexities of a building site. A good site analysis allows the designer to make informed decisions to take full advantage of solar orientation, prevailing wind direction, topography, and tree species and locations. Adjacent streets & traffic patterns should be considered, functional synergies with surrounding buildings created, and special environmental elements featured.

Item #1 highlights the importance of building orientation. Energy efficiency and environmental impacts are affected by decisions made early in the planning process. For example, when the building is oriented along the east-west axis, the designer can take advantage of natural daylighting, which reduces the need for electrical lighting and resultant energy consumption. Note: Urban infill projects do not usually have the opportunity to orient the building to the sun, due to tight site constraints. However, project designers are encouraged to think about maximum solar exposure within the limits of the surrounding buildings.

Item #2 encourages designers to consider prevailing winds in their design. Proper orientation can help move vehicle exhaust away from the school. In addition, winter winds and snow accumulation should be considered to predict and prevent snowdrifts in driveways and in front of air intakes.

Earth berms, forests, and other natural features can help inform layout of the school building during early design. Likewise, manmade structures, such as storage structures for biomass fuel, can be sited carefully to provide protection to the site. Plantings of deciduous trees provide shade to the school during warmer months and access to sunlight at the end of autumn when the trees' leaves have fallen. These suggestions refer to items #3 and #4 above.

Importation or exportation of soil can be costly in terms of both dollars and environmental impact. Item #5 encourages the conservation of the environment by minimizing excavation and importation of non-native

soils. By optimizing Cut & Fill (ideally 1:1) during clearing and excavation, use of native soils is maximized, reducing the adverse impacts on the site.

In item #6, creating physical connections means considering features on adjacent properties and designing the site layout such that it promotes their use.

Item #7 encourages early consideration of opportunities for on-site renewable energy generation. Biomass heating, for example, can be an effective option for many school projects, but the building and site layout must take into consideration the need for wood chip storage. Wind electricity generation may also make sense for many schools, but wind resources should be investigated early and designers should investigate the best location for turbines on the school site. Likewise, electricity generated by the sun through photovoltaic (PV) panels may be an option, but PV panels must be installed such that they will not be shaded and should be oriented toward the south.

Documentation

For all strategies attempted, submit Site Analysis sketches outlining all of the site's features before the building is placed, AND submit the following for individual strategies for at least 4 of the items listed in the credit and identified by the numbers below. Site layouts and design narratives may be combined where appropriate.

1. Site layout and design narrative signed by the project architect, showing how the project responds to natural daylighting.
2. Site layout and design narrative signed by the project architect, showing how the project responds to prevailing winds.
3. Site layout and landscape design narrative signed by the project architect, showing how the existing topography and tree coverage respond to weather or deflect unwanted noise.
4. Site layout and landscape design narrative signed by the project architect, showing how the intended or existing plantings increase shade in the summer and allow solar gain in the winter.
5. Provide a Cut/Fill Analysis report that shows a maximum of a 5% deviation from a 1:1 ratio. Please do not submit the entire report—only the sections that identify the report and support the intent of a 1:1 ratio of excavation and infill with native soils.
6. Site layout and design narrative signed by the project architect, showing how the project responds to natural features and/or adjacent buildings.
7. Site layout and design narrative signed by the project architect, showing how the project responds to opportunities for on-site renewable energy generation.

Audit Requirements

1. Submittal for cut & fill that shows a maximum of a 5% deviation to a 1:1 ratio.
2. Verification shall be made during site visits of other items claimed under this credit.

TRANSPORTATION

Purpose: Reduce pollution and land development impacts from automobile use.

CREDIT 2.1: LOCATE NEAR PUBLIC TRANSIT

1 point	SC 2.1. Public Transportation. Locate building within ¼ mile of a commuter rail, light rail or subway station, or within 1/8 mile of one or more bus lines.

The energy use and pollution associated with transportation often dwarfs the total lifetime energy used by the school itself. Locating the site close to public transportation, encouraging use of public transportation and carpooling by minimizing parking, and creating bike facilities and safe walking/biking access all reduce the automobile-related pollution. Some school districts offer reduced or subsidized fares for students and staff using public transportation. If sufficient capacity exists, schools can use public transportation to replace district provided bus service.

Documentation

Provide an area map locating transportation lines within the distance to school as noted. Measure from the main entrance of the school building (i.e. front door), and mark bus stops or stations for commuter rail, light rail, or subway lines.

Audit Requirements

None.

CREDIT 2.2: PEDESTRIAN/BIKE ACCESS

1 point	SC 2.2. Provide sidewalks or walkways that extend at least to the school entrance at the public way; AND provide bike lanes or sidewalks that connect to residential areas at least ¼ mile from the school entrance at the public way; AND provide suitable means for securing bicycles for 5% or more of building occupants. For elementary schools, count only students in the 4th grade and above as building occupants. Staff should be included in all calculations regardless of the age of the school's students. Please note that the addition of bike lanes or sidewalks from the school to surrounding neighborhoods may not be an expense that is reimbursed by the Massachusetts School Building Authority.

The purpose of this credit is to provide safe access to the school by students and staff who choose to walk or ride their bicycles to school. To protect pedestrians, sidewalks or walkways must extend to the end of the school entrance at the public way. To protect and encourage cyclists, bike lanes or sidewalks must extend at least a quarter mile from the school entrance into surrounding neighborhoods

Documentation

1. Site plan highlighting bike racks and details regarding how many bikes each rack can accommodate. Complete calculation for necessary number of bike racks in Application Template.

2. Site plan highlighting all sidewalks extending to the end of the school entrance at the public way. Site plan highlighting bike lanes or sidewalks that extend from the school entrance at the public way to ¼ mile away from the school.

Audit Requirements

1. Supply submittal for bike racks.

2. Verification shall be made during site visit of bike path that leads at least ¼ away from the entrance of the school at the public way.

CREDIT 2.3: MINIMIZE PARKING

1 point	SC 2.3. Minimize Parking **New Construction**: Size parking capacity to meet, but not exceed, minimum local zoning requirements, AND provide preferred parking spaces and signage for 5% of total parking spaces for carpools, vanpools, and low-emitting, fuel-efficient vehicles (e.g. hybrids and vehicles using bio-diesel, CNG or other low-emitting fuel or technology), AND size parking capacity not to exceed: • High schools: 2.25 spaces per classroom plus parking for 20% of students. • Elementary and Middle: Three parking spaces per classroom. **Major Renovations:** Add no new parking compared to existing conditions, AND provide preferred parking spaces and signage totaling 5% of total parking spaces for carpools or vanpools and for low-emitting, fuel-efficient vehicles (e.g. hybrids, vehicles using bio-diesel, CNG or other low-emitting fuel or technology).

Excess parking spaces encourage increased automobile use, contribute to urban heat island effects, and can increase pollution from stormwater runoff. Design parking so as not to exceed listed amounts, and include clearly marked, preferred parking areas for carpools, vanpools and low-emitting, fuel-efficient vehicles. For the purposes of making calculations for this credit, classrooms include:

- General classrooms
- Art rooms
- Music classrooms
- Computer labs
- Science labs
- Special needs collaborative, and remedial classroom space

Documentation

New Construction

1. Site plan showing parking layout (indicate total number of parking spaces). Highlight preferred parking spaces.
2. Signage schedule highlighting Preferred Parking signage
3. Indicate number of classrooms (as defined for this credit) and total number of students.

Major Renovation

1. Existing site plan showing existing parking conditions (indicate total number of parking spaces)
2. Site plan of new parking layout (indicate total number of parking spaces). Highlight preferred parking spaces.
3. Signage schedule highlighting Preferred Parking signage

Audit Requirements

Provide the submittal for preferred parking signage.

Resources

LEED™ *Reference Guide*: Site Credit 4.

STORMWATER MANAGEMENT

Purpose: Manage stormwater after construction to control erosion and runoff, recharge local aquifers, and maintain the quality of receiving waters.

CREDIT 3: POST-CONSTRUCTION STORMWATER MANAGEMENT

1 Point	SC 3. Implement a stormwater management plan that results in a 25% decrease in the peak runoff rate for the 2-year, 24-hour storm from existing to developed conditions, AND design a stormwater system that results in a 25% decrease in runoff volume for the 100-year, 24-hour storm from existing to developed conditions.

Stormwater runoff is precipitation that flows over surfaces on the site and enters either the sewage system or receiving waters. Stormwater carries sediment and pollutants from the site into the sewage system or local bodies of water. The cumulative runoff throughout the local area requires significant investments in municipal infrastructure to handle peak runoff loads.

Reducing the amount of runoff is the most effective way to minimize its negative impacts. Many strategies exist to limit stormwater runoff, including the following:

- Significantly reduce impervious surfaces, maximize on-site stormwater infiltration, and retain pervious and vegetated areas.
- Capture rainwater from impervious areas of the building for groundwater recharge or reuse within the building.
- Use green/vegetated roofs.

Documentation

Provide a Stormwater Management Plan showing a net decrease in peak rate of discharge of at least 25% from existing to developed conditions as demonstrated by the 2 year-24 hour storm, and show that the volume runoff from the 100-year, 24-hour storm is 25% less than the same storm event for existing conditions.

Audit Requirements

None.

Resources

Stormwater Management, Volume One: Stormwater Policy Handbook by MA Dept of Environmental Protection and MA Office of Coastal Zone Management, March 1997: http://www.mass.gov/dep/water/laws/swmpolv1.pdf

Stormwater Management, Volume Two: Stormwater Technical Handbook by MA Dept of Environmental Protection and MA Office of Coastal Zone Management, March 1997: http://www.mass.gov/dep/water/laws/swmpolv2.pdf

LEED™ *Reference Guide*: Site Credit 6: Stormwater Management.

OUTDOOR SURFACES

Purpose: Reduce heat islands to minimize impact on microclimate and human and wildlife habitat.

CREDIT 4.1: DESIGN TO REDUCE HEAT ISLANDS, NON-ROOF

1 Point	SC 4.1. Provide shade (within five years) on at least 30% of non-roof, impervious surfaces on the site, including parking lots, walkways, plazas, etc. OR use light-colored/ high-albedo materials (a Solar Reflectance Index* (SRI) of at least 29) for 30% of the site's non-roof, impervious surfaces OR use a combination of shading and high-albedo materials for 30% of the site's non-roof surfaces. **SRI or Solar Reflectance Index is calculated according to ASTM E 1980. Reflectance is calculated according to ASTM E 903, ASTM E 1918 or ASTM C 1549. Emittance is calculated according to ASTME E 408 or ASTM C 1372. Product information is available from the Cool Roof Rating Council Web site,* www.coolroofs.org.

Note that the "heat island effect" is largely an urban phenomenon. Dark surfaces, such as pavement, cladding, and roofing absorb heat and radiate it back to surrounding areas. In a city, where there are many dark, heat absorbing surfaces, infrared radiation can easily boost temperatures by 10˚F or more. The heat island effect increases the need for air conditioning (and therefore electricity consumption) and is detrimental to site plantings, local wildlife, and maintaining comfortable temperatures.

Employ design strategies, materials, and landscaping designs that reduce heat absorption of exterior materials. Note Solar Reflectance Index (SRI) requirements in the drawings and specifications. Provide shade using native or climate-tolerant trees and large shrubs, vegetated trellises, or other exterior structures supporting vegetation. Substitute vegetated surfaces for hard surfaces. Explore elimination of blacktop and the use of new coatings and integral colorants for asphalt to achieve light colored surfaces.

Documentation

1. Site plan or landscaping plan showing trees that contribute to shade and/or highlight light-colored, non-roof impervious surfaces.
2. Calculations for shading and/or high-albedo materials:

Shading

- Identify all non-roof impervious surfaces on the project site and sum the total area.
- Identify all trees that contribute shade to non-roof impervious surfaces. Highlight these trees on the plan you submit.
- Calculate the shade coverage provided by these trees after five years of growth on the non-roof impervious surfaces on June 21 at solar noon to determine the maximum shading effect.
- Determine the total area of shade provided for non-roof impervious surfaces. Divide by total—result must be 30%.

For use of light-colored/ high-albedo materials:

- Identify all non-roof impervious surfaces on the project site and sum the total area.
- Calculate the total area of non-roof impervious surfaces designed with light-colored/high-albedo materials. Divide by total—result must be 30%.

- If light-colored/ high-albedo materials are used to achieve this credit, provide specifications showing an SRI of 29 or better.

Note: Applicants may achieve 30% coverage by adding together areas of shading and areas of light-colored/high-albedo materials to total 30%.

Audit Requirements

1. Submittals for all light-colored and regular colored paving materials and for tree plantings.

2. Verification shall be made during site visit of paving and planting material.

CREDIT 4.2: DESIGN TO REDUCE HEAT ISLANDS, ROOF

1 Point	SC 4.2. Cool Roofs. Use roofing materials having a Solar Reflectance Index* (SRI) as listed below for roof type for a minimum of 75% of the roof surface. OR install a "green" (vegetated) roof for at least 50% of the roof area. Roof Type Slope SRI Low-Sloped Roof <=2:12 78 Steep-Sloped Roof >2:12 29

Cool roofs can significantly reduce school cooling loads and urban heat island effects by reflecting the sun's energy, instead of absorbing, retaining, and radiating it into the occupied spaces below. Both the reflectivity and emissivity are important characteristics of cool roofs. A solar reflectance of 0.0 means that all the solar energy hitting the surface is absorbed and none is reflected. Emissivity is the ability of a material to shed infrared radiation.

Schools that do not have significant cooling loads may not wish to pursue this credit. In these cases, a cool roof can actually result in more energy use in the heating season than it will offset in cooling loads during the summer. Energy modeling can help predict which facilities would be likely to experience an energy benefit by installing a cool roof. To find qualifying roof products, see the Cool Roof Rating Council website at www.coolroofs.org.

Documentation

1. Roof plan highlighting roofing areas with appropriate SRI ratings and/or green roof areas.
2. Reference specifications for roofing material, showing compliance with SRI's of 29 or 78, according to the slope of the roof, and Green Roof specifications, if applicable. Designate the CSI number, section, and page number.
3. Complete calculation in the Application Template

Audit Requirements

1. Submittals for roofing material showing compliance with Solar Reflective Indexes of 29 or 78 for sloped and non-sloped roofs, respectively.

2. Submittals for green roof, if applicable.

Resources

LEED *Reference Guide* Credit 7: Landscape and Exterior Design to Reduce Heat Islands

Cool Roof Rating Council—www.coolroofs.org

William F. Stanley Elementary School—Waltham. A white roof was installed to reduce heat island effect.

OUTDOOR LIGHTING

Purpose: Minimize light pollution and energy waste by controlling light output, uplight, glare, and light trespass, while providing for the safe and comfortable nighttime use of the school. Improve nighttime visibility and safety through glare reduction and high quality lighting.

CREDIT 5: EXTERIOR LIGHT POLLUTION REDUCTION

2 Points	SC 5. Complete all of the following listed below: 1. To avoid over lighting and energy waste, meet but do not significantly exceed the lighting limits in IESNA Recommended Practices. Refer to the current versions of the of the Illuminating Engineering Society of North America (IESNA) RP-33 Lighting for Exterior Environments, IESNA/ANSI RP-8 American National Standard Practice for Roadway Lighting, and IESNA RP-20 Lighting for Parking Facilities. Designers may specify slightly higher initial light levels to account for lamp depreciation over time. 2. Specify IESNA Cutoff or IESNA Full Cutoff for all exterior-site and building-mounted lighting fixtures greater than 13 watts. Specify IESNA Full Cutoff for all exterior-site and building-mounted lighting fixtures greater than 70 watts. Cutoff and Full Cutoff fixtures may not be the adjustable type. 3. Where the school property line abuts residential properties, parks, or natural wildlife areas, light levels must not exceed 0.01 footcandles ten (10) feet over the property line. This can be achieved by location and shielding of fixtures and therefore preventing unwanted light trespass. 4. All exterior-site and building-mounted lighting fixtures that are only needed when the school is open for nighttime use (i.e., not needed all night and/or every night) shall be controlled with easily accessed manual switch controls. 5. Lamp types and controls: Do not install mercury vapor lamps. Incandescent and incandescent halogen sources shall not be used for exterior lighting unless controlled by a motion sensor. 6. Signs, monuments, and flags. Fixtures for school signs, monuments, and flags are limited to 50 watts per fixture, and they must incorporate shielding devices such as hoods, louvers, and source shields. The fixtures are exempt from the cutoff and full cutoff requirements of #3—as defined by IESNA RP-33. 7. Sports field lighting design must follow IESNA RP-6. Fixtures must incorporate extensive shielding to minimize and redirect stray light. Controls must be provided that encourage the shutting off of the lights when the sports field is not in use. Fixtures specifically for lighting sports fields are exempt from the Full Cutoff requirements listed in #3.

Good outdoor lighting supports the comfort and safety of the school community. Low glare, appropriate light levels, optical guidance, and good color rendition are attributes of good outdoor lighting. Good lighting also prevents light pollution that impacts the night sky or trespasses onto neighboring properties.

There are some simple ways to avoid light pollution from school signs and flagpoles. Signs should be lighted from the top down if feasible and use spot lighting fixtures, not flood light fixtures. Self-lit signs,

such as fluorescent signs, are not encouraged, but they are not prohibited. If flags are not lowered each night, then protocol dictates that they must be lighted. This may be accomplished with a maximum of two fixtures of 50 watts. Fixtures with narrow beam distribution should be used in order to concentrate light onto the flag.

Documentation

1. A photometric site plan produced by computer modeling with the following information:
   - Horizontal illuminances at ground level on a minimum ten-foot by ten-foot grid with the property line clearly marked in **bold** on photometric plan and abutting residential properties, parks, or natural wildlife areas noted.
   - Average, maximum, and minimum illuminances for each area (walkways, parking lots, driveways, building entries, etc.)
   - The location and mounting height of all site and building mounted exterior fixtures clearly indicated, with fixture type designations relating to the lighting fixture schedule.
   - Light loss factors used for each fixture type.
2. Specifications for exterior lights, showing that Cutoff and Full Cutoff requirements are met. Also supply an exterior lighting fixture schedule with manufacturers and model numbers, and manufacturer's spec sheets, with a clear description of the specified lamping, wattage, IESNA cutoff classification, and shielding accessories for each fixture.
3. Provide a letter signed by the project's site lighting designer verifying that items 1 through 7 will be executed on this project. All 7 points must be addressed.

Audit Requirements

1. Submittals for exterior light fixtures.

2. Submittals for shielding accessories for exterior light fixtures.

Resources

Illuminating Engineering Society of North America; www.iesna.org

Illuminating Engineering Society of North America, Lighting for Exterior Environments, An IESNA Recommended Practice, RP-33-99

Illuminating Engineering Society of North America, Lighting Parking Facilities, RP-20-98

Illuminating Engineering Society of North America, Recommended Practice for Sports and Recreational Area Lighting, IESNA RP-6-01

Illuminating Engineering Society of North America, Roadway Lighting, IESNA RP-8-00

The International Dark Sky Association, www.darksky.org

LEED *Reference Guide*: Site Credit 8: Light Pollution Reduction. www.usgbc.org

National Lighting Product Information Program, Lighting Answers, vol. 7 issue 2, Light Pollution, www.lrc.rpi.edu/programs/NLPIP

Water

INDOOR WATER SYSTEMS

Purpose: Maximize water efficiency within buildings to reduce the burden on municipal water supply, aquifers, and wastewater treatment systems.

The growing value of potable water in Massachusetts underscores the importance of lowering demand. Efficient water consumption naturally reduces the amount of water pumped from the ground or transported from reservoirs to cities and towns. In addition, water efficiency reduces the cost and amount of sewage needing treatment after use. Because water-efficient devices can vary in quality and performance, specify only durable, high performance fixtures.

A maximum of 2 points can be earned with the Indoor Systems credits. Well designed, water efficient systems may earn one point by reducing the overall amount of potable water used in the schools (Water Credit 1.1) and by reducing the amount of potable water used for sewage conveyance (Water Credit 1.2).

PREREQUISITE 1: INDOOR WATER USE REDUCTION –20%

Required for Green Schools	WP 1. Employ strategies that, in aggregate, reduce potable water use by 20% beyond the baseline calculated for the building (not including irrigation) after meeting the Energy Policy Act of 1992's fixture performance requirements.

This prerequisite requires reductions in total water use; therefore all significant water uses are included in the calculations. To quantify water use reductions, use spreadsheets in the Application Template showing baseline and design water uses. Sample calculations are provided below.

Develop a water use baseline including all water-consuming fixtures, equipment, and seasonal conditions according to methodology outlined below. Specify water-conserving plumbing fixtures that exceed the Energy Policy Act (EPAct) of 1992's fixture requirements in combination with ultra high efficiency or dry fixture and control technologies. Specify high water efficiency equipment (e.g., dishwashers, faucets, etc.).

Table 1—EPAct Fixture Performance Requirements

Fixture	EPAct Requirement
Toilets	1.6 gallons/flush
Urinals	1.0 gallons/flush
Showerheads	2.5 gallons/minute
Faucets (Non-Lavatory)	2.5 gallons/minute
Lavatory Faucets	0.5 gallons/minute or 0.25 gallons/cycle - Massachusetts State Plumbing Code*
Replacement Aerators	2.5 gallons/minute
Metering faucets	0.25 gallons/cycle

** For lavatory faucets in public buildings, Massachusetts code supersedes EPAct fixture performance requirements.*

Table 2—Design Indoor Water Consumption Calculation

Fixture Type	Flow-rate	Duration	Occupants	Daily uses	Water use
Low-flow Toilet (male)	1.6 gal/flush	1 flush	500	1	800
Waterless Urinal (male)	0.0 gal/flush	1 flush	500	2	0
Low-flow Toilet (female)	1.6 gal/flush	1 flush	500	3	2400
Bathroom Sink	0.5 gal/min	0.17 min	1000	3	255
Low-flow Shower	1.8 gal/min	5 min	100	1	900
Low-flow Kitchen Sink	1.8 gal/min	45 min	2	2	324
Efficient Clothes Washer	20 gal/load	1 load	-	10	200
				Total Daily Volume	4879
				Number of School Days	180
				Subtotal	878,220
				Minus Collected Rainwater	(396,000)
				Design Total Annual Volume	482,220

For the baseline calculation, create a similar spreadsheet but change only the type of fixture and its associated design details. The baseline calculation for this example would therefore be:

Table 3—Baseline Indoor Water Consumption Calculation

Fixture Type	Flow-rate	Duration	Occupants	Daily uses	Water use
Conventional Toilet (male)	1.6 gal/flush	1 flush	500	1	800
Conventional Urinal (male)	1.0 gal/flush	1 flush	500	2	1000
Conventional Toilet (female)	1.6 gal/flush	1 flush	500	3	2400
Bathroom Sink	0.5 gal/min.	0.5 min	1000	3	750
Conventional Shower	2.5 gal/min	5 min	100	1	1250
Kitchen Sink	2.5 gal/min	45 min -	2	2	450
Clothes Washer	40 gal/load	1 load -	-	10	400
				Total Daily Volume	7,050
				Number of School Days	180
				Baseline Total Annual Volume	1,269,000

Comparing the two spreadsheets, the water-efficient fixtures reduced potable water use by:

% Savings = 1 – (Design Total Annual Volume / Baseline Total Annual Volume)

= 1 – (482,220/1,269,000) = 0.62 = 62%

Therefore, this design would earn two points because overall potable water use has been reduced by over 30%.

Documentation

1. Perform calculations as outlined above using the MA-CHPS Application Template.

2. Reference specification section for all water closets, urinals, lavatories, kitchen and janitor sinks, showerheads, clothes washers etc. Designate the CSI number, section, and page number.
3. Submit a plumbing fixture schedule.

Audit Requirements

Provide submittals for all water closets, urinals, lavatories, kitchen and janitor sinks, showerheads, clothes washers and all items associated with this credit.

Resources

LEED™ *Reference Guide*: Water Credit 2: Innovative Waste Water Technologies; Water Credit 3: Water Use Reduction.

CREDIT 1.1: INDOOR WATER USE REDUCTION – 30%

1 point	WC 1.1. Exceed the potable water use reduction by 30% beyond the calculated baseline determined in Water Prerequisite 1.

To earn a credit, specify fixtures that further reduce water consumption by 30%beyond the baseline established in Water Prerequisite 1.

Documentation

Documentation for this credit is already fulfilled by submitting documentation for Water Prerequisite 1.

Audit Requirements

The audit requirement for this credit is already fulfilled by submitting documents for the audit requirement in Water Prerequisite 1.

CREDIT 1.2: REDUCE WATER USED FOR SEWAGE CONVEYANCE

1 point	WC 1.2. Reduce the use of potable water for building sewage conveyance by a minimum of 50% through the utilization of water-efficient fixtures, use of rainwater catchment systems, or both.

Use water-efficient fixtures and/or site-collected water to reduce the amount of potable water used for sewage conveyance. Only those sources that produce blackwater, such as toilets and urinals, are included in this calculation. Rainwater is suitable for flushing toilets and urinals, which typically produce the largest amounts of wastewater in a school. A growing number of schools are collecting rainwater for use in sewage conveyance—the Dedham Middle School, Whitman-Hanson Regional High School, and Woburn High School are three examples. At the Whitman-Hanson school, the water generated from HVAC condensate is also collected in the rainwater collection tank and used for toilet flushing.

To quantify water use reductions, use the MA-CHPS water use spreadsheet in the Application Template to determine baseline and design water consumption. List each fixture that produces blackwater, the amount of daily uses, number of occupants, and total water use. A water-efficient design for a 1,000-student school is shown in Table 4. The example assumes the use of low-flow toilets and waterless urinals, with all fixtures either using no water or using non-potable water. For tips on water storage in underground tanks and cisterns, review the "Rainwater Collection and Water Storage" section (page 30).

Table 4—Design Sewage Conveyance Calculation

Fixture Type	Flow-rate	Duration	Occupants	Daily Uses	Water Use (gal)
Toilets (male)	1.6 gal/flush	1 flush	500	1	800
Waterless Urinals (male)	0.0 gal/flush	1 flush	500	2	0
Toilets (female)	1.6 gal/flush	1 flush	500	3	2400
Total Daily Volume					3200
				Number of School Days	180
				Design Total Annual Volume	576,000
				Minus Collected Rainwater	(396,000)
				Total Potable Water Used for Sewage Conveyance	180,000

Calculate Daily Water Use per fixture using the following equation:
Daily Water Use = (Flow-rate) (Duration)(Occupants)(Daily Uses)

1. Sum Daily Water Volumes for each fixture to find Total Daily Volume.
2. Multiply the Total Daily Volume by the number of school days for Total Annual Volume.
3. Subtract the amount of reclaimed water used to find Total Potable Water Used for Sewage Conveyance.

For baseline indoor water consumption calculations, use a similar spreadsheet in the Application Template, but change only the type of fixture and its associated design details. For baseline calculations, assume flow rates outlined by the Energy Policy Act of 1992's fixture performance requirements:

Table 5—Baseline Sewage Conveyance Calculation

Fixture Type	Flow-rate	Duration	Occupants	Daily uses	Water use (gal)
Conventional Toilet (male)	1.6 gal/flush	1 flush	500	1	800
Conventional Urinal (male)	1.0 gal/flush	1 flush	500	2	1000
Conventional Toilet (female)	1.6 gal/flush	1 flush	500	3	2400
				Total Daily Volume	4200
				Number of School Days	180
				Baseline Total Annual Volume	756,000

Comparing the two spreadsheets, the water-efficient fixtures reduced potable water use for sewage conveyance by:

% Savings = 1 – (Design Total Annual Volume / Baseline Total Annual Volume) = 1 – (180,000/756,000) = 0.76 = 76%

Therefore, this design would earn one point because potable water used for sewage conveyance has been reduced by 76% through using reclaimed water in the toilets and urinals. Note that the low-flow fixtures by themselves were not enough to earn this credit.

Documentation

1. Perform calculations as outlined above using the MA-CHPS Application Template.
2. Reference specification section for blackwater fixtures, highlighting the gallons per flush. Designate the CSI number, section, and page number.

Audit Requirements

Provide submittals for all water-closets and urinals.

Resources

LEED™ *Reference Guide*: Water Credit 2: Innovative Waste Water Technologies; Water Credit 3: Water Use Reduction.

OUTDOOR WATER SYSTEMS

Significant amounts of potable water are currently used to irrigate landscaping and playing fields. Although the New England region receives an average of several inches of rainfall per month, expanding development is increasing the demand for potable water. As more water is withdrawn to meet demand, aquifers and rivers can be stressed to the point of creating water shortages and ecological changes to rivers and streams. Summer dry spells cause the most stress to underground and surface waters as water is withdrawn for irrigation and other outdoor activities but is not replaced by rainfall.

Use of potable water for irrigation can be minimized by specifying water conservative plants and grasses, collecting and using rainwater for irrigation and/or using highly water-efficient irrigation systems where irrigation is absolutely necessary (e.g., playing fields). When specifying drought-resistant plants, determine soil composition and ensure that existing soils will support the plants to be specified. Consider all operating and maintenance costs of any irrigation equipment specified. If irrigation is necessary, make arrangements to irrigate during early morning hours to maximize irrigation efficiency and minimize evaporation.

CREDIT 2.1: NO PERMANENT IRRIGATION FOR LANDSCAPING

1 point	WC 2.1. Do not install permanent irrigation systems for watering non-playing field landscaped areas AND specify drought resistant plants or grasses in these areas so that irrigation is not needed beyond plant establishment.

Documentation

Provide a letter signed by landscape architect certifying that permanent irrigation systems have not been specified for non-playing field areas AND that only drought resistant plants and grasses have been specified for these areas. Letter must clearly state that no irrigation, manual or otherwise, will be needed in these areas after plants are established. Letter must also indicate the species of drought resistant plants and grasses that have been specified.

Audit Requirements

Provide submittals for area planting that are associated with this credit.

Resources

LEED™ Reference Manual: Water Credit 1: Water Efficient Landscaping.

Local water utility staff, water efficient landscape consultants, Certified Irrigation Designers (www.irrigation.org), and Master Gardeners are also good resources for helping achieve this credit.

CREDIT 2.2: WATER REDUCTION AND SPORTS TURF MANAGEMENT

1 point	WC 2.2. Reduce the irrigation needs of athletic fields by specifying appropriate soils and drought tolerant grasses for all sports fields. Specify organic content of athletic field soils to be between 3% and 7% of total soil content. Specify athletic field grasses for new fields to be a mixture of 80% Kentucky bluegrass cultivars and 20% perennial rye grass cultivars, spread at a rate of 3 to 4 lbs/1000 ft^2. Any in-ground irrigation systems used for athletic fields must have soil moisture meters or equivalent technology to prevent operation of irrigation systems when adequate ambient moisture is available to the turf.

Soil Types

The best types of soil for playing fields are 3% to 7% organic content and fall into the U.S. Department of Agriculture soil categories:

Table 6 - Watering Requirements by Soil Type

Soil Type	Watering Requirements
Loamy sand	1 in. per week
Sandy loam	1 in. per week
Loam	1 in. per week

Artificial Turf

Artificial sports turf can be considered as a substitute for soil-based athletic fields. While no credits for artificial turf are available under the Water section, if the turf contains recycled material, it may qualify for points under the Materials section of this document. Check with manufacturers to ascertain whether recycled materials are incorporated into their turf products.

Rainwater Collection and Water Storage

Some schools opt to use rainwater catchment systems with cisterns or underground storage tanks to provide water for irrigation and for flushing water closets. These supplementary systems can significantly decrease water demand by drawing on stored water instead of municipal water supplies or drinking water wells.

A rainwater catchment system should be designed with a water storage capacity for sewage conveyance and/or irrigation in typical years under average conditions. In other words, oversizing water storage to meet drought conditions may be costly and could increase maintenance requirements. On the other hand, undersizing storage may simply result in a system that is too small to significantly offset potable water consumption. Rainwater collection and storage systems should be designed to avoid stagnation that could lead to mold growth and accumulation of bacteria.

The underground storage tanks and cisterns could at times run dry during drought conditions. Therefore, it is acceptable for tanks and cisterns to connect to wells or municipal water supplies.

Dedham Middle School. Two 25,000 gallon tanks were installed underground at the Dedham Middle School. The tanks will store rainwater collected from the school roof. The rainwater catchment system was sized so that it can provide 100% of the water needed for sewage conveyance for the whole building and 100% of water needed to irrigate a small ball field on the site. No potable water will be used for irrigation or toilet flushing. Photo credit: Dore & Whittier Architects, Inc.

Documentation

1. Reference specifications for organic soil content for all athletic fields included in the project. Designate the CSI number, section, and page number.
2. Reference specifications for new athletic field grass mixtures of 80% Kentucky bluegrass cultivars and 20% perennial rye grass cultivars, spread at a rate of 3 to 4 lbs/1000 ft^2. . Designate the CSI number, section, and page number.
3. Reference specifications for high efficiency irrigation technologies including devices that save water such as soil moisture meters. Designate the CSI number, section, and page number.

Audit Requirements

Provide submittals for organic soil content, mixture of turf species for new athletic fields, and for high efficiency irrigation technologies such as soil moisture meters.

Resources

LEED™ Reference Manual: Water Credit 1: Water Efficient Landscaping.

Local water utility staff, water efficient landscape consultants, Certified Irrigation Designers (www.irrigation.org/), and Master Gardeners are also good resources for helping achieve this credit.

CREDIT 2.3: IRRIGATION SYSTEM COMMISSIONING

1 point	WC 2.3. Create an irrigation commissioning plan and complete installation review during construction, performance testing after installation, and documentation for ongoing operations and maintenance.

Documentation

1. Reference specifications for an irrigation commissioning plan. Designate the CSI number, section, and page number. State that irrigation commissioning plan must include:
   - Identify which entity will prepare the irrigation commissioning plan and who will perform the commissioning tasks.
   - Review of irrigation system installation during construction, with record of deficiencies found and corrected,
   - Performance testing and documentation of results (as compared to specified performance) at least once during the first year of installation, and
   - Site-specific documentation detailing maintenance requirements and frequency and operation procedures including a recommended irrigation schedule to apply 1 inch of water per week to athletic fields.
2. Acceptance testing shall be included in the specifications and performed on the following, if applicable:
   - Irrigation pipes and fittings. Under static conditions the system pressure loss shall not exceed 3 psi over a one hour time period.
   - Irrigation heads and coverage. The system shall have a measured distribution uniformity (lower quarter) of no less than 65%.
   - Back-flow devices.
   - Automatic sensors, timers and other controls.

- For equipment not listed, the design team shall provide acceptable test results, and the contractor shall certify that the tests were performed and the equipment performs as specified.

Audit Requirements

Supply a letter signed by commissioning agent verifying requirements for performance testing of irrigation equipment and actual performance have been met.

Resources

LEED™ Reference Manual: Water Credit 1: Water Efficient Landscaping.

Local water utility staff, water efficient landscape consultants, Certified Irrigation Designers (www.irrigation.org/), and Master Gardeners are also good resources for helping achieve this credit.

Energy

Environmental Impacts

Purpose: Reduce environmental impacts and operational costs associated with consuming energy.

Energy-efficient schools save money while conserving non-renewable energy resources and reducing atmospheric emissions of pollutants and greenhouse gases. The Massachusetts Climate Protection Plan, released in May 2004, supports the construction of energy efficient schools throughout the Commonwealth whether facilities are renovations/additions or new construction. The minimum requirements of the Massachusetts Building Energy Code, while effective, can be met and exceeded using numerous cost-effective, practical, and straightforward measures.

Energy modeling is an effective tool for achieving energy savings and is a critical part of an integrated design approach. Various combinations of building systems can be modeled using specialized software to show payback calculations for different energy saving measures. The most effective energy modeling is an iterative process whereby different combinations of measures, such as daylighting, HVAC systems controls, lighting systems and controls, and energy recovery equipment, are modeled to determine the best payback and to minimize operational costs.

Commissioning, maintenance, and training are vitally important to the performance of the school and are key to maintaining energy efficiency. Commissioning involves a rigorous quality assurance program that ensures the building and its systems are built and operated as designed and that the school district receives the proper training and documentation needed to operate and maintain the building. No building can perform optimally without adequate maintenance. Training is critically important for maintenance staff to thoroughly understand how to maintain and operate the building systems. When staff turnover occurs, appropriate documentation must be on hand in order to train new team members.

Prerequisite 1: Elimination of CFC-Based Refrigerants

Required	EP 1. Zero use of CFC-based refrigerants in all building Heating Ventilating Air Conditioning & Refrigeration (HVAC&R) systems. *Exception*: Components of HVAC&R systems that are NOT being replaced as part of a renovation project are not subject to this prerequisite.

Because Chlorofluorocarbon (CFC)-based refrigerants have been found to adversely affect atmospheric ozone levels, the following prerequisite requires the use of alternative refrigerants in Heating, Ventilation, Air Conditioning, and Refrigeration (HVAC&R) systems.

Documentation
A letter from the owner confirming that CFC-containing salvaged HVAC&R systems will not be imported into the new or renovated school facility.

Audit Requirements
None.

COMMISSIONING AND TRAINING

Purpose: Verify that fundamental building elements and systems are designed, installed, and calibrated to operate as intended, and provide for the ongoing accountability and optimization of building energy performance over time.

Do not underestimate the value of commissioning. Buildings, even simple structures, are complex systems of electrical, mechanical, and structural components. High performance buildings are healthy, efficient, environmentally sensitive structures whose performance can be significantly affected if the building has not been designed following the owner's project requirements or constructed according to the designers' specifications. Commissioning is a rigorous quality assurance program administered by a knowledgeable third party that ensures the building performs as expected.

This prerequisite requires a commissioning process to be in place early in the design process and carries through to the post-occupancy 10-month warranty review and subsequent completion of a commissioning report.

PREREQUISITE 2: COMMISSIONING

Required	EP 2. Implement ALL of the following fundamental best practice commissioning procedures: 1. Engage an independent, third-party commissioning agent. The agent may be hired by the owner, the owner's project manager, or by the Massachusetts School Building Authority (MSBA). The commissioning agent will be responsible for commissioning the following critical building systems. *Electrical Systems*: • Lighting controls (daylight, occupancy, timing switches, etc.); • On-site renewable solar electric or wind systems • Cable access television • Telecommunication systems • Electrical distribution systems • Life and safety systems *Mechanical Systems:* • HVAC systems (such as hot water systems, chilled water systems, central air systems, ventilation systems); • Domestic hot water systems;

	• Energy management system • Renewable energy heating systems *Plumbing Systems:* • Flow control devices • Pumping systems • Special hazardous waste treatment systems (e.g. for lab wastes) • Domestic hot water systems • Graywater systems (if applicable) 2. Conduct a 10-month warranty, post-occupancy review. 3. Review design intent and basis of design documentation. 4. Conduct a focused review of the design prior to the construction documents phase. 5. Conduct a focused review of the construction documents when close to completion. 6. Include commissioning requirements in the construction documents. 7. Develop and utilize a commissioning plan. 8. Conduct a selective review of contractor submittals of commissioned equipment. 9. Review the Operations & Maintenance manual. 10. Verify installation, functional performance testing (including off-season testing), training, and operations and maintenance documentation. A minimum 15% sampling strategy for testing terminal units and repetitive units is permissible. All major systems must be tested. 11. Complete a commissioning report.

The following list describes each of the commissioning steps listed above in greater detail.

1. *Engage a commissioning agent*. The commissioning agent (CA) directs the commissioning process and should be hired in time for the design development phase. The commissioning services must be performed by an independent third party, i.e. not part of the design or construction management of the project.
2. *Ten month warranty, post-occupancy review*. The commissioning contract shall contain provisions for a 10-month warranty and post-occupancy review. The review is intended to bring the design, construction, commissioning, and facility staff together to solicit the facility staff's comments, suggestions, and areas of concern regarding the systems in their first year of operation. Warranties on any commissioned systems should be reviewed and deficient equipment should be identified and a plan for resolution developed.
3. *Review design intent and basis of design documentation.* The architect and the design engineer are the most appropriate people to create this document, which should list the owner's project requirements and design intent for each of the systems or features to be commissioned. The CA will review this document, and a copy of the review shall be provided to the owner.
4. *Conduct a focused review of the design prior to the construction documents phase*. This review early in the design process should be focused on an assessment of how well the design meets the owner's design intent. Assessment should be made as to how the design meets the functionality, utility performance, maintainability, sustainability, cost, and indoor environmental quality

requirements outlined in the design intent. Evidence of the review is to be documented in the commissioning report.

5. *Conduct a focused review of the construction documents when close to completion.* This review should be conducted prior to issuing the construction documents for bid and captured in the commissioning report. The review should answer these questions:
   - Does the design meet the owner's design intent?
   - Does the design allow for proper maintenance access?
   - Do the construction documents clearly detail the construction requirements?
   - Do the construction documents clearly define the commissioning requirements?
6. *Include commissioning requirements* in the construction documents. All commissioning requirements must be integrated into the construction documents to clearly specify the responsibilities and tasks to be performed. Of particular importance are the delineation of the contractors' responsibilities regarding documentation, functional performance testing, occupant and operator training, and the creation of the operations and maintenance manuals.
7. *Develop commissioning plan.* The commissioning plan includes a list of all equipment and systems to be commissioned, delineation of roles for each of the primary commissioning participants, and details on the scope, timeline, and deliverables throughout the commissioning process.
8. *Conduct a selective review of contractor submittals of commissioned equipment*. Contractor submittals for the systems and equipment included in the commissioning scope shall be reviewed by the CA in conjunction with the designer's review. The review shall focus on the ability of the submitted product to meet the owner's requirements and review comments shall be provided to the owner and the design team.
9. *Review Operations & Maintenance manual.* This manual is intended to help future operating staff to understand and optimally operate and maintain the commissioned systems. The general contractor compiles the O&M manual and the commissioning agent reviews it for completeness and readability. The O&M manual must contain the following items:
   - As-built sequences of operations for all equipment as provided by the design professionals and contractors, including time-of-day schedules and schedule frequency, and detailed point listings with ranges and initial setpoints.
   - Ongoing operating instructions for all energy- and water-saving features and strategies.
   - Seasonal operational guidelines.
   - Recommendations for recalibration frequency of sensors and actuators by type and use.
   - Guidelines for continuous maintenance of the owner's project requirements (operational requirements) and basis of design (basis of operation).
10. *Verify installation, functional performance testing, training, and operations and maintenance documentation for each commissioned system and feature.* The commissioning agent must complete off-season functional performance testing. This is the heart of the commissioning process.
11. *Complete a commissioning report.* The report must show that the building's systems have met the design intent and specifications, have been properly installed, are performing as expected, and that proper O&M documentation and training have been provided. The report should include a compilation of all commissioning documentation described in this credit, including complete functional testing results and forms and should note any items that have not been resolved at the time the report is issued.

Documentation

1. Copy of signed commissioning services contract that clearly outlines the systems to be commissioned and the services to be performed by the commissioning agent including items #1-11 listed in the text box on commissioning.
2. Reference specifications for commissioning, or if commissioning specifications are embedded in separate divisions of the project manual, provide the relevant specifications (e.g., lighting systems, HVAC, Building Automation System, plumbing, renewable energy systems). Designate the CSI number, section, and page number that highlight compliance with this requirement.

Audit Requirements

The commissioning report from the project will be reviewed with the expectation that the commissioning process was completed to the fullest extent possible.

The commissioning report shall contain:

- An executive summary that describes issues identified during the commissioning process
- A final version of the design intent and basis of design .
- Single line diagrams of each commissioned system.
- A summary table listing dates of tests and results of tests.
- A summary table listing functional performance tests results, dates of tests, and results; include blank test forms and a recommended schedule for ongoing benchmarking.
- Corrective action log summarizing deficiencies and actions taken to correct them. Include any deficiencies that were identified but not corrected.
- Operations and Maintenance Documentation—cover sheet and table of contents with a letter stating that a review of the O & M manuals was completed by the commissioning agent AND that the school district received the manuals. Please note where the manuals are now kept (central district workshop, individual school custodian office, etc.). O&M manuals apply to systems that have been commissioned.
- A training syllabus for O&M sessions.

Resources

LEED™ Reference Manual: Energy and Atmosphere Prerequisite 1: Energy and Atmosphere Credit 3

ASHRAE Guideline 1-1996: The HVAC Commissioning Process

ASHRAE Guideline 4-1993: Preparation of Operations & Maintenance Documentation for Building Systems

Commonwealth of Massachusetts State Building Code; 780 CMR Chapter 13 MA Regulations. www.mass.gov/bbrs/780CMR_Ch13.pdf

PREREQUISITE 3: FUNDAMENTAL BUILDING SYSTEMS TRAINING

Required	EP 3. Training is the foundation of effective maintenance programs and is an essential tool to protect indoor air quality and maintain superior energy performance. Facility Staff Training: Facility staff must receive training and operation and maintenance documentation on the building systems identified below: *Electrical Systems*: • Lighting controls (daylight, occupancy, timing switches, etc.); • On-site renewable solar electric or wind systems • Cable access television • Telecommunication Systems • Electrical distribution systems • Life and safety systems *Mechanical Systems*: • HVAC systems (such as hot water systems, chilled water systems, central air systems, ventilation systems); • Domestic hot water systems; • Energy Management System; • Renewable energy heating systems *Plumbing Systems:* • Flow control devices • Pumping systems • Special hazardous waste treatment systems (e.g. for lab wastes) • Domestic hot water systems • Graywater systems (if applicable) Teacher/Administrative Staff Training: Teachers, administrators, and support staff must be offered training on operations of lighting, heating, and cooling systems in classrooms, offices, gyms, auditoriums etc. A User's Guide, explaining basic systems operations, should be developed and posted in each room of the school.

The design and construction of the school may incorporate all the latest high performance features, yet problems can occur simply because important information is not transferred from the design and construction teams to the school facilities and maintenance staff, or to the building occupants. Training the facilities and maintenance staff is essential to the performance of the building, but is often not performed or is hastily completed. Training the teachers and administration staff in how they can control their room environments provides them with an understanding that will help the facilities staff keep the building performing optimally.

The owner's project manager shall verify that the following required actions are planned for and executed.

- Provide Operations & Maintenance training for facilities and maintenance staff on all major building systems from the bulleted list above. It is typical to specify training requirements in the construction contract and subsequently, the general contractor arranges for equipment vendors, controls contractors etc. to teach building operators how to use and maintain their new equipment. The training is overseen by the commissioning agent to ensure that the facilities staff receives the materials and hours of training stipulated in the construction contract. It is vital that facility and maintenance staff attend these training sessions.
- Compile an Operations & Maintenance Manual: The manual should provide detailed operations and maintenance information for all equipment and products installed; it should be specifically written for maintenance and facility staff. The construction contractor typically furnishes the O&M manuals and the commissioning agent reviews the manual for completeness and clarity.
- Create a short, classroom "User's Guide" for teachers and administrative staff explaining how to operate their room lighting and HVAC systems. A User's Guide should be posted in every room of the school.
- Conduct Operations & Maintenance training for staff. Provide a short introduction for all school staff explaining how classroom systems work such as lighting and temperature controls, particularly if classrooms have operable windows and air conditioning systems.

Documentation

Provide a letter of intent signed by the school's facility manager and school building committee chair explaining:

1. Who will oversee facility/maintenance staff training; in the letter, explain the general content of the training to take place;
2. Who will provide the Operations and Maintenance Manuals for maintenance staff;
3. Who will train teachers and administrative staff on HVAC and lightings systems; and
4. Who will prepare the "User's Guides" for each room in the school.

Audit Requirements

Provide a copy of the User's Guide created for the all rooms in the school.

Resources

ASHRAE Guideline 1-1996: The HVAC Commissioning Process

ASHRAE Guideline 4-1993: Preparation of Operations & Maintenance Documentation for Building Systems

LEED™ *Reference Guide*: Energy and Atmosphere Prerequisite 1 and Credit 3: Fundamental Building Systems Commissioning and Additional Commissioning

ENERGY EFFICIENCY

PREREQUISITE 4: EXCEED CODE BY 20%

Required for Green Schools	EP 4. Exceed the MA Building Energy Code (780 CMR Chapter 13) by 20% on an energy cost basis in accordance with either the Performance-based OR the Prescriptive approaches defined below.

Select either the Performance Approach or the Prescriptive Approach for determining energy cost savings. The Performance Approach is presented first followed by the Prescriptive Approach. The two approaches may not be combined. Select one or the other.

Performance Approach

Model the school using LEED energy savings calculations protocol (version 2.1 of LEED) to show that it will achieve 20% less energy cost than a Massachusetts energy code minimum building (780 CMR Chapter 13), regulated loads only. Calculations may be made according to ASHRAE 90.1-2001, Section 11- Energy Cost Budget Method, Informative Appendix G Performance Rating Method to account for the contribution of certain green design features. Some exceptions and simplifications to the energy cost budget (ECM) method may be allowed—see Appendix B at the end of this document for additional information.

The following are acceptable energy modeling software programs: various versions of DOE-2 such as PowerDOE, and E-Quest, VisualDOE, DOE-2.1e. ***Equivalent programs may be used with permission, provided they are submitted for approval prior to use.*** Contribution from on-site generation can be counted towards energy savings. Savings should be based on regulated loads only as described in the LEED savings calculation protocol.

Performance Approach

The energy modeling report submitted must include the following key elements:

- Executive summary with the results of the energy modeling study stated clearly.
- Facility and site narrative describing the type of construction, hours of operation, and size and configuration of building. Describe the mechanical system, lighting systems, equipment loads, domestic hot water system, and any renewable energy systems.
- Narrative summarizing the analysis methodology, the baseline design, and results of energy modeling.
- Table summarizing and comparing the different systems in the 'as designed' case versus the baseline case, such as code compliant boilers, chillers, motors, windows, and wall and roof insulation versus higher efficiency equipment.
- Table that details utility incentives (where applicable) for each incentivized energy conservation measure (ECM) and provide a column that shows the simple payback for the incremental cost of each ECM.
- Table summarizing the annual energy consumption for the design case and the base case (see template below).

Table 7—Annual Energy Consumption, Design Case versus Base Case

Item	Annual Energy Consumption				
	Electricity (kWh)	Natural Gas, oil, other (therms, gallons, other)	Total site Btu (MM Btu)	Total Source Btu (MM Btu)	Total Energy Costs ($)
Design case					
Base case					
Savings subtotal					
Contribution from on-site generation					
Total Savings					
Total % Savings					

- Table summarizing cost savings (see template below). Use actual retail utility rate structures and schedules. In the absence of a local utility rate schedule, use the energy rates provided in the LEED *Reference Guide* under Energy and Atmosphere Credit 1.

Table 8—Cost Savings Summary

Measure	Units	Baseline Building	As Designed Building	Savings
Electricity consumption	kWh			
Electricity consumption/ft²	kWh/ft²			
Electricity cost	$			
Electricity cost/ft²	$/ft²			
Natural gas, oil or other fuel consumption	Therms, gallons, other			
Natural gas, oil or other fuel consumption/ft²	Therms, gallons, other/ft²			
Natural gas, oil or other fuel cost	$			
Natural gas, oil or other fuel cost/ft²	$/ft²			
Total site energy consumption	MMBtu			
Total site energy consumption/ft²	MMBtu/ft²			
Total site energy cost	$			
Total site energy cost/ft²	$/ft²			

- An electronic version of all input and output data from the school building energy model must be submitted with the application for green school certification.
- Paper copies of each of the following energy modeling reports for both the base case and the as-designed case (These should also be made available to the school's facilities personnel as well):

  Building Energy Consumption per End Use (BEPU)—This report shows annual building energy use according to energy type (electricity, natural gas, etc.) and energy end use (lights, space heating, space cooling, fans, etc). The energy use should be shown in the actual units of consumption, such as kWh for electricity, therms for gas, etc.

  Building Energy Consumption per End Use (BEPS)—This report is very similar to the BEPU report described above. The difference is that the values in this report are all converted into the same units (MMBtu), allowing a direct comparison of end-use intensities.

Energy Cost Summary (ES-D or ES-E)—This report summarizes the monthly energy consumption and cost for all utility rates that are defined for/applicable to the project (electric rate, gas rate, etc.).

Summary of Spaces Occurring in the Project (LV-B)—This report provides a list of all the zones occurring in the model along with the assigned lighting wattage, number of people, equipment wattage, infiltration amount, square footage, and volume.

Building Peak Load Components (LS-C)- This report provides a breakdown of the building cooling and heating peak loads according to the source of the loads (walls, roof, windows, occupants, light, equipment, infiltration, etc). This report does not include the loads due to ventilation air.

Equipment Loads and Energy Use for Central Plant Components (PS-C)—This report would be required only for projects that include central plant equipment such as boiler(s) or chiller(s). For each central plant component this report provides annual heating and/or cooling load, the electrical and fuel consumption, and performance information in a bin format, including hours of operation at different partial loads, and the total annual hours of operation.

Examples of each of these reports are included in Appendix E.

Important: Conversion factors for electricity are: 3,412 Btu/kWh per site Btu and 10,000 Btu/kWh per source Btu.

Prescriptive Approach

Applicants may demonstrate compliance with Energy Prerequisite 4 by incorporating the prescriptive package of energy conservation measures listed below. The prescriptive measures have been researched and are modeled to achieve at least 20% greater building energy efficiency than a comparable baseline building that meets the minimum requirements of the current Massachusetts State Building Code, 780 CMR Chapter 13 (Energy Efficiency).

1. *Lighting Power Density (LPD):* Average Installed lighting equipment power density shall not exceed 1.0 Watts/ft^2 for the entire school.
2. *Automatic Light Reduction:* Control systems, such as occupancy sensors, timed lighting schedules, and/or timed switches, that shut interior lights off when spaces are unoccupied for 15 minutes or more shall be employed in all the following spaces:

   - General classrooms
   - Art rooms
   - Music rooms
   - Science rooms
   - Computer rooms
   - Library
   - Physical education
   - Special needs, remedial, and collaborative space
   - Cafeteria
   - Administration spaces

   Exceptions:

   - Emergency lighting
   - Night security lighting
   - Task Lighting
   - Spaces with only one luminaire
   - HID luminaires shall reduce the connected lighting load in a reasonably uniform illumination pattern by at least 40 percent.

3. *Dimming/Switching/Bi-Level Control for Lighting.* Light switches shall be installed such that more than one level of artificial illumination is possible. Note the addition to the code (Massachusetts Building Code 780 CMR 1308.2.3) shown below in bold typeface.

   Each perimeter **and non-perimeter regularly occupied space** enclosed by ceiling-height partitions shall have a manual control to allow the occupant to uniformly reduce the connected lighting load by at least 50%.

   This requirement applies to the following spaces:

   - General classrooms
   - Art rooms
   - Music rooms
   - Science rooms
   - Computer rooms
   - Library
   - Physical education
   - Special needs, remedial, and collaborative space
   - Cafeteria
   - Administration spaces

   Exception: HID luminaires shall reduce the connected lighting load in a reasonably uniform illumination pattern by at least 40 percent.

4. *Daylight Responsive Lighting Control:* Incorporate daylighting throughout the school building such that 15% of the installed electrical lighting wattage is dimmed or turned off when sufficient natural light is present.

   Exception: Theatrical lighting, specialty lighting, and task lighting.

5. *Fenestration Performance:* The U-Factor of the window assemblies shall not exceed 0.45 for metal-framed window systems and 0.35 for non-metal-framed window systems. For further guidance, see *Advanced Buildings Benchmark Version 1.1*, pp. 62–63. Massachusetts is in climate zone "5 Humid."

6. *Premium Efficiency Motors:* For all motors greater than or equal to 1 horsepower, install premium efficiency motors as defined by the National Electrical Manufacturers Association (NEMA). Link: www.nema.org/stds/complimentary-docs/upload/MG1premium.pdf.

7. *Mechanical System Design*: Employ best practices design techniques to improve system performance and meet ASHRAE Standard 55. The design engineer shall document the following actions in the design process.

   When sizing the heating and cooling equipment, perform load calculations using interior load assumptions that are consistent with sustainable design practices. This includes using the design interior lighting, accounting for the actual glazing characteristics, providing credit for displaced loads if displacement systems are used, and base miscellaneous loads on field-verified measurements or field-based research rather than typical owner programming assumptions. Where not feasible, document the non-standard load assumptions for owner concurrence.

   When sizing the fan and air distribution systems, document fan-sizing calculations with zone-by-zone load calculations. Perform calculations to determine critical path supply duct pressure loss. Compare fitting selections for oval duct where feasible to lower leakage and reduce pressure loss. Separate all fittings in medium and high–pressure ductwork by several duct diameters to reduce system effects wherever feasible. Where possible, provide automatic dampers on exhaust in lieu of barometric dampers to reduce fan power and increase barometric relief.

Perform a second set of calculations using part-load conditions (maximum likely load and/or standard operating conditions). This includes using benchmark data, average daytime temperatures and non-peak solar gain, and other assumptions to define part-load conditions for the heating and cooling system. Include diversity factors for interior loads and other factors that will allow proper assessment of part-load operation.

Describe the system operation at these conditions and describe features of the design that will facilitate efficient operation at these part-load conditions. Document how the system will deliver ventilation air, maintain comfort in accordance with ASHRAE Standard 55 and operate in an energy efficient manner.

Source: Advanced Buildings Benchmark Version 1.1, New Buildings Institute

8. *Boilers/Burners Selection and Sizing:* When the school design includes a boiler plant, the size of any single boiler shall not exceed 50% of the calculated design building heating load. For power burners larger than 400,000 BTU/h, fully modulating burners shall be used.

   Boilers are typically sized to meet the building heat loss and ventilation air heating loads at winter design temperature conditions without taking credit for internal heat sources such as lights, equipment, and people. This results in the boilers that are oversized for most of their operating conditions. Oversized boilers are inefficient due to fixed losses, such as radiative heat losses. These fixed losses are inversely proportional to the boiler load. Therefore, radiative heat losses, which can be as little as 1% at full load, can become 5% to 20% at partial load.

   On top of fixed losses, inefficiencies also result when boilers "short cycle"; which occurs when an oversized boiler quickly satisfies the heating load, cycles off for a brief period, and then cycles on again. Larger boilers with power burners that have pre- and post- purge cycles are particularly inefficient when they undergo short cycling, since with each cycle, air used to flush the boiler during purging is heated and vented to the chimney. Short cycling also adversely affects the boiler life because the boiler is rapidly heated then cooled, and burner motors are cycled on and off, reducing the longevity of the boiler heat exchanging surfaces and burner motors.

   To avoid these problems, size the boiler plant to efficiently meet both the peak and part load heating requirements of the building. Provide multiple boilers, each sized at some fraction less than 50% of the design building heating load, and use modulating burners on larger boilers so that they can operate over a wide load range without short cycling.

   Exception: Boiler plants that utilize condensing boilers or plants where each boiler capacity is smaller than 300,000 BTU/h.

9. *Boiler Efficiency*. If installing gas-fired boilers, they must have a rated thermal efficiency of at least 80% or a rated combustion efficiency of at least 83%. If installing oil-fired boilers, the boilers must have a rated thermal efficiency of at least 83% or a combustion efficiency of 85%. Boilers shall be rated according to test methods referenced in the current Massachusetts Building Code, Chapter 13.

10. *Efficient Cooling Equipment*: Install air conditioning equipment in accordance with Advanced Buildings—Benchmark Version 1.1 prescriptive criteria "Mechanical Equipment Efficiencies Requirements" addressing package terminal air conditioners, heat pumps, electric chillers, and absorption chillers. Refer to Appendix A in this document for efficiency values. Tables in Appendix A listing heat pump efficiencies, unitary air conditioning, and condensing unit efficiencies are provided by the Consortium for Energy Efficiency (CEE), which developed specifications for use in voluntary energy-efficiency programs. Tables in Appendix A for package terminal air conditioners and chillers were developed by the New Buildings Institute for their Advanced Buildings - Benchmark efficiency criteria. Be sure to check the web links for updated

versions of the efficiency tables.
Source: Advanced Buildings -Benchmark, New Buildings Institute Version 1.1.
www.poweryourdesign.com/ABbenchmark.pdf
Consortium for Energy Efficiency—www.cee1.org/com/hecac/hecac-tiers.pdf

11. *CO_2-Based Demand Controlled Ventilation*: Install CO_2-based demand controlled ventilation systems in large volume areas with variable occupancy, such as gymnasiums, cafeterias, auditoriums and cafetoriums.

    Demand controlled ventilation is a "smart" ventilation strategy for spaces with varying levels of occupancy throughout the day. For example, the school cafeteria may be occupied sparsely most of the school day except for lunch periods when occupancy reaches maximum levels. Carbon dioxide sensors installed in the occupied space measure the CO_2 in the air, compare the CO_2 levels to levels measured by outdoor CO_2 sensors, and continuously adjust the amount of fresh air delivered based on the number of people in the room. When more people are in the room, the airflow increases, when there are fewer, the ventilation rate decreases proportionally. This ventilation control method avoids heating and cooling large quantities of outside air when few people are using the space. Gymnasiums and auditoriums are also examples of spaces that can have high design ventilation air volumes but, for most of the time, are not fully occupied.

    When siting the outdoor CO_2 sensor, it is critical to locate the sensors away from other sources of CO_2, such as exhaust vents, which would provide a false reading of ambient carbon dioxide levels. To maintain the design ventilation rates, it is also critical that the CO_2 sensors are recalibrated at intervals according to the manufacturer's recommendations. This recalibration of the sensors must be written into the school's preventive maintenance plan.

    Use the language below to guide design assumptions. *Note the addition to the code (Massachusetts Building Code 780 CMR 1305.3.6.2) shown below in* **bold typeface**.

    Systems with design outside air capacities greater than 3000 cfm serving areas having an average design occupancy density exceeding **50** people per 1000 ft^2 shall **automatically reset outside air rates based on the CO_2 concentration levels in the space as compared to the outdoor CO_2 level.**

    Exceptions: Systems with heat recovery. The minimum effectiveness of the heat recovery system must be 50% for total energy recovery or 65% of sensible heat recovery.

12. *Variable Speed Control:* Individual pumps serving variable flow systems and VAV fans having a motor horsepower of 7.5 hp or larger shall have controls and/or devices (such as variable speed control) that will result in pump or fan motor demand of no more than 30% of design wattage at 50% of design flow.

    Note 1: If an HVAC unit has a 7.5 hp or larger supply fan, but the return fan is smaller than 7.5 hp, the requirement of this measure still applies. This assumption is made since the control method used on the supply fan is almost always the same as that used on the return fan.

    Note 2: In some types of boiler plant configurations (especially where larger, non-condensing boilers are used in conjunction with primary-only variable flow hot water loops), it is possible that a net energy cost penalty may occur if the hot water pump is optimized through this measure (i.e. variable frequency drives (VFD's) are installed for hot water pump capacity control). Although VFD's reduce electricity consumption for pumping, they simultaneously reduce heat energy from the pump. As a result, more thermal energy is required from the boiler plant. Depending on one's utility rate structure, the efficiency of the boiler plant at part loads, and other factors, VFD's for the hot water loop may result in a net energy cost increase for the building. In such circumstances,

the VFD requirement for the hot water pump may be waived. Quality engineering analysis shall be applied to assess whether such exception may be relevant to a particular project.

Documentation

Prescriptive Approach

1. *Lighting Power Density*—U.S. Department of Energy's ComCheck output clearly indicating lighting power densities for the entire building.
2. *Automatic Light Reduction*—Supply a letter signed by the project's professional engineer certifying that the automatic lighting reductions will be achieved according to the criteria listed above. Include a brief narrative of the approach used; reference appropriate specification sections for lighting controls and drawing numbers of lighting control schedules and drawings showing the control devices as designed. For computer scheduled lighting reductions, provide a narrative describing how your system works including relevant software and hardware.
3. *Dimming/Switching/Bi-Level Control for Lighting*—Supply a letter signed by the project's professional engineer certifying that the above criteria for controlling lighting levels will be achieved. Include in the letter references to appropriate specification sections for dimming, switching or bi-level controls; reference drawing numbers of dimming, switching, or bi-level control schedules; and reference drawings showing the devices as designed.
4. *Daylight Responsive Lighting Control*—Supply a letter signed by the project's electrical professional engineer showing the total lighting wattage of the school building and the total lighting wattage controlled by daylight responsive lighting controls. The ratio of daylight responsive wattage to the total installed wattage should be 15% or greater.
5. *Fenestration Performance*—Reference fenestration specifications. Please designate the CSI numbers, sections, and page numbers that highlight the U-Factor for each type of fenestration.
6. *Premium Efficiency Motors*—Reference specification sections. Designate the CSI numbers, sections, and page numbers that highlight compliance with this requirement.
7. *Mechanical System Design*—Provide documentation that shows the methodology for calculating peak load and partial load conditions. Please model your response on a sample letter provided in the Application Template.
8. *Boilers/Burners Selection and Sizing* —Supply a letter signed by the project's mechanical professional engineer certifying that the above criterion is met. The letter should include the assumptions and calculations that guided the sizing of burners and boilers. Include with the letter, outputs from HVAC system design software (e.g. Trane/Trace or Carrier software, or other equivalent software) showing peak load design parameters.
9. *Boiler Efficiency*—Reference specification sections for boiler efficiency. Designate the CSI number, section, and page number that highlight compliance with this requirement.
10. *Efficient Cooling Equipment*—Reference specification sections for efficient cooling equipment. Designate the CSI number, section, and page number that highlight compliance with this requirement.
11. *CO_2 -Based Demand Controlled Ventilation*—Reference appropriate specification sections indicating the implementation of CO_2 sensors and their placement away from outdoor sources of CO_2 exhaust OR reference specifications calling for heat recovery systems with a minimum effectiveness of 50% or total energy recovery of 65% sensible heat.
12. *Variable Speed Control*—Supply a letter by the project's mechanical professional engineer certifying that the criteria for Variable Speed Control systems are met; include references to appropriate specification sections and drawings.

Audit Requirements- Prescriptive Approach and Performance Approach

In the project commissioning report, the summary of functional testing reports will be reviewed for lighting controls (daylight, occupancy, light switching), HVAC systems (such as hot water systems, chilled water systems, central air systems, ventilation systems), domestic hot water systems, and energy management system. The commissioning report should verify that the requirements for performance testing and actual performance have been met.

Resources

2000 International Energy Conservation Code, by International Code Council, Country Club Hills, IL

Advanced Buildings E-Benchmark Version 1.1 by New Buildings Institute, Inc. January 2005 Edition. www.newbuildings.org.

ANSI/ASHRAE/IESNA Standard 90.1-1999 Energy Standard for Buildings Except Low-Rise Residential Buildings. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. Atlanta, GA.

ANSI/ASHRAE/IESNA Standard 90.1-2001 Energy Standard for Buildings Except Low-Rise Residential Buildings. Section 11 Energy Cost Budget Method, Informative Appendix G Performance Rating Method. American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., Atlanta, GA. www.ashrae.org/template/AssetDetail/assetid/30208.

Commonwealth of Massachusetts State Building Code; 780 CMR Chapter 13 MA Regulations. www.mass.gov/bbrs/780CMR_Ch13.pdf

Energy Star—www.energystar.gov/—Energy Star is a federal government-sponsored program helping businesses and individuals protect the environment through superior energy efficiency.

Rebuild America—www.rebuild.org/sectors/ess/index.asp—Rebuild America manages the Energy Smart Schools program.

LEED™ *Reference Guide*: Energy and Atmosphere Credit 1: Optimized Energy Performance

CREDIT 1: SUPERIOR ENERGY PERFORMANCE

Integrate the design of all significant building systems including HVAC, lighting, and building envelope to reduce source energy of the proposed design below what is required by 780 CMR Chapter 13.

Performance Approach

See points available below	EC 1 – Utilize the Performance Approach from Energy Prerequisite 4 for quantifying energy cost savings. Points are awarded according the percentage saved over a baseline building.

1 point	22.5% reduction in total energy cost compared to 780 CMR Chapter 13
2 points	25% reduction in total energy cost compared to 780 CMR Chapter 13
3 points	27.5% reduction in total energy cost compared to 780 CMR Chapter 13
4 points	30% reduction in total energy cost compared to 780 CMR Chapter 13
5 points	32.5% reduction in total energy cost compared to 780 CMR Chapter 13
6 points	35% reduction in total energy cost compared to 780 CMR Chapter 13
7 points	37.5% reduction in total energy cost compared to 780 CMR Chapter 13
8 points	40% reduction in total energy cost compared to 780 CMR Chapter 13
9 points	42.5% reduction in total energy cost compared to 780 CMR Chapter 13
10 points	45% reduction in total energy cost compared to 780 CMR Chapter 13

To obtain credit, the school must achieve at least **22.5%** less energy cost than a Massachusetts energy code minimum building, based on regulated loads only. Model the school using LEED energy savings calculations protocol (version 2.1 of LEED NC). Points are awarded for higher percentages of savings as indicated in the table above. No partial points are allowed. See Appendix B at the end of this document for additional information about energy modeling assumptions.

Documentation

Follow the same instructions for documentation as in Energy Prerequisite 4: Exceed Code by 20% using the performance approach. The energy modeling report submitted must follow the same format, and an electronic version of all input and output data from the school building energy model must be submitted with the application for green school certification.

Audit Requirements

The audit requirement for this credit is already fulfilled by submitting documents for the audit requirement in Energy Prerequisite 4.

Prescriptive Approach

Note: The following prescriptive credits cannot be combined with the Performance Approach above.

1 point	EC 1 – Prescriptive Approach #1. Reduce the thermal conductance of the building envelope by insulating the walls and the roof to the levels required in Tables 2.1.1 and 2.1.2 (pp. 54-55) of the Advanced Buildings Benchmark v1.1 (climate zone 5). See Appendix C.
1 point	EC 1 – Prescriptive Approach #2. Meet the requirements of IEQ Credit 1.2, Daylighting in Classrooms AND ensure that 40% of the installed electrical lighting wattage throughout the school is dimmed or turned off when sufficient natural light is present.

Documentation (EC 1 Prescriptive Approach #1)

Reference specifications for R-value of walls and R-value of roof insulation. Designate the CSI number, section, and page number that highlight compliance with this requirement.

Documentation (EC 1 Prescriptive Approach #2)

Provide a letter signed by the project architect indicating that 40% of the installed electrical lighting wattage will be dimmed or turned off when sufficient natural light is present.

Audit Requirements (EC 1 Prescriptive Approach #1)

Provide submittals for wall and roof insulation.

Audit Requirements (EC 1 Prescriptive Approach #2)

Provide submittals for daylight dimming equipment including dimmable ballasts and photosensors.

Michael E. Capuano Early Childhood Center—Somerville. Spray foam insulation was used to create a tighter building envelope that will save energy and money. Photo credit: HMFH Architects, Inc.

CREDIT 2: MINIMIZE AIR CONDITIONING

2 points	EC 2. Design 90% of permanent classrooms without air conditioning.

Earlier in this document, in the Site section, school districts are encouraged to optimize use of school facilities by the local community. This credit is intended to reward the avoidance of air conditioning, and its associated energy consumption, in classrooms where it is not needed due to limited summer use. The decision to include or not include air conditioning must be carefully weighed by the school building committee. If summer use is likely to increase, then this credit may not be appropriate for your facility.

The purpose of this credit would be defeated if window air conditioning units were later installed in classrooms. Therefore, the school district must be confident that the schedule of use in the summer will not include classrooms. If this does change in the future, the school district should look at upgrading its air conditioning systems and require energy efficient cooling systems (e.g., ENERGY STAR-rated systems)

For this credit, classrooms are defined as:

- General classrooms
- Art rooms
- Music rooms
- Science rooms
- Computer rooms
- Special needs, remedial, and collaborative space

Documentation

1. Designate the appropriate HVAC drawings and highlight on the drawings what elements comply with this credit.

2. Calculate the total number of classrooms without air conditioning versus the total number of classrooms. The credit is achieved if 90% of the classrooms are designed without air conditioning.

   Note: ASHRAE Standard 55-2004 thermal comfort standards are not expected to be met in non-air conditioned classrooms.

Audit Requirements

None.

ALTERNATIVE ENERGY SOURCES

CREDIT 3: RENEWABLE ENERGY

See points available below	EC 3. Use on-site alternative energy sources for electricity production or heating/cooling. The table below shows the point levels corresponding to the percentage of energy cost savings supplied by alternative energy sources as compared to the total energy cost of the as-designed school, regulated loads only.

Table 9—Electricity and Thermal Energy Producing Renewables

Electricity-Producing Renewables	Percentage Renewable Energy of As-Designed Energy Costs
2 points	1.0%
3 points	3.0%
4 points	5.0%
5 points	7.0%
6 points	10.0%
Thermal Energy-Producing Renewables	**Percentage Renewable Energy of As-Designed Energy Costs**
2 points—Solar thermal	1.0%
3 points—Solar thermal	2.0%
2 points—*Biomass/Biodiesel heating/cooling	10.0%
3 points—*Biomass/Biodiesel heating/cooling	20.0%
**See Glossary for definitions of biomass, bio-gas, biodiesel, and bio-oil.*	

On-site alternative energy has many benefits. Alternative energy sources such as photovoltaics and wind turbines use the sun and wind instead of non-renewable, polluting sources, such as coal, oil or natural gas. Producing energy on-site also eliminates the environmental impacts of transmission losses associated with remote sources and transportation emissions associated with fuel delivery. On-site sources can be very effective components of school curricula, educating students on a wide variety of energy and science issues. And on-site alternative energy production has the added advantage of increasing fuel diversity. Utilizing indigenous resources such as woody biomass, biogas, wind, and solar energy is increasingly important as New England is rapidly becoming dependent upon natural gas.

Berkshire Hills Regional Middle School—Great Barrington. A 56 kW solar photovoltaic array was installed on the school's south-facing roof. The array will supply 9.9% of the school's as-designed energy needs.

As reported by the U.S. Department of Energy, the average school in the "cool and humid" climate zone, which includes Massachusetts, uses energy for heating, cooling and lighting in the following proportions:

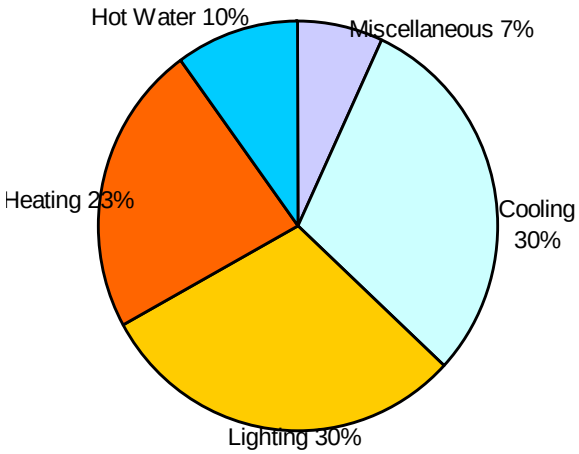

Figure 1—School Energy Use Distribution

School Energy Use Distribution for schools in the "cool and humid" climate zone, which includes MA. Source: Energy Design Guidelines for High Performance Schools: Cool and Humid Climates; US DOE, Office of Building Technology

When considering the contributions of renewable energy technologies on the school's energy loads, it is helpful to know what the greatest loads are and why. Clearly, a building with partial air-conditioning would narrow the slice of the energy pie for the consumption of electricity for air-conditioning. It is typical for schools to consume one-third of their energy on heating and hot water and almost two-thirds on electricity.

Newton South High School. A total of 60 kW of solar photovoltaic panels were installed in an array on the field house roof (pictured above) and as field house awnings. The combination of the solar arrays with many other energy efficiency measures mean that Newton South High School will be 35.4% more energy efficient than a code-compliant building. Photo credit: Drummey Rosane Anderson Architects.

Electricity Generating Renewables

For purposes of this credit, electricity-generating renewables are defined as follows:

- Photovoltaics
- Wind
- On site hydropower
- Landfill gas
- Low emission, advanced biomass power conversion technologies, such as woodchip-based biomass, biodiesel, bio-oil, and bio-gas.

Great Falls Middle School/Turners Falls High School—Montague. A 34 kW solar photovoltaic array was installed on the roof of the school's swimming pool building. The array supplies 2.3% of the school's as-designed energy needs. Photo credit: Symmes, Maini & McKee Associates (SMMA).

Note: Projects proposing to use electricity-generating biomass technology for MA-CHPS credits are advised to seek eligibility for the Massachusetts Renewable Portfolio Standards from the Massachusetts Division of Energy Resources (Pursuant to 225 CMR 14.00; section 14.06(5), available at www.mass.gov/doer/rps/index.htm).

Financial Benefits Beyond CHPS: Net-Metering

In Massachusetts, electricity consumers that install an on-site generating system with a rated capacity of 60-kW or less can qualify for net metering. Under net metering, the output of such a system is either consumed immediately by the loads active within the building or sent to grid, spinning the electric meter backwards and effectively avoiding purchases of electricity from the utility at its retail rates. This is particularly helpful for wind and solar systems, which are intermittent in nature. Larger systems (above 60-kW) may benefit at retail rates in the event the output displaces utility-provided power on a simultaneous basis. Surplus output during any billing period (for net metered systems) or instantaneously (for other systems) will be bought by the utility at its wholesale rates.

Michael E. Capuano Early Childhood Center—Somerville. A small 400 Watt wind turbine was installed on the roof of the school's garden shed for demonstration and instructional purposes. Photo credit: HMFH Architects, Inc.

Renewable Energy Certificates

The environmental attributes for each megawatt hour of electricity generated by certain on-site, electricity-generating renewables (including all electricity-generating technologies that are eligible for this credit) may be captured by Renewable Energy Certificates (REC's). These REC's may have monetary value and can be traded on the open market. Schools that claim points under this credit may only sell REC's associated with the electrical energy generated in excess of that needed to claim Alternate Energy Source points.

Schools have the opportunity to utilize renewable energy generated off-site under Policy and Operations Credit 4.1, 4.2: Clean Energy.

Thermal Energy-Producing Renewables

For purposes of this credit, thermal energy-generating renewables are defined as follows:

- Solar thermal
- Biomass heating/cooling

Schools can use solar thermal collectors to provide hot water for lavatories, showers, kitchens, and pools. Although solar thermal systems will be most productive in the summer months, collector technologies are advanced to work effectively in cold climates. Nonetheless, those schools with significant summer hot water demands will benefit most from solar water heating.

Woody biomass heating systems are commercially available for school heating and are widely used in Vermont. Projects in Massachusetts include the Athol-Royalston School and Mt. Wachusett Community College. These biomass heating systems serve as the primary heating system for the schools with smaller conventionally-fuel boilers as backup and for shoulder seasons. Systems are fully automated.

Biodiesel is a renewable bio-based fuel that can be blended with conventional heating oil and used in a heating boiler or furnace. Typically, biodiesel is blended at a 10% or 20% rate. The use of biodiesel requires no modifications to the boiler and improves system performance and maintenance, and reduces emissions. Biodiesel suppliers are available in Massachusetts.

If the biomass system is designed to co-fire with a non-renewable fuel (i.e., accommodate less than 100% biofuel), the points claimed must be pro-rated accordingly. For example, if plans call for use of 20% bio-oil

This woodchip conveyor belt delivers woodchips to the biomass gasifier and boiler heating system. Photo Credit: Biomass Energy Resource Center, Montpelier, VT.

and 80% conventional fuel, only 20% of energy generated by the system can be counted as renewable for purposes of calculating points.

Documentation

Points are awarded for this credit based on the annual energy cost savings provided by the renewable energy system or systems compared to the annual energy costs for regulated building energy loads. To achieve this credit, the annual energy consumption for the completed school building (regulated loads only) will need to be estimated. See the Application Template for specific calculations.

If the project followed the Performance Approach of Energy Prerequisite 4, then no further documentation is required. However, if the Prescriptive Approach was taken to meet Energy Prerequisite 4, then an energy model must be developed to show the savings generated by renewable energy. The following are acceptable energy modeling software programs: various versions of DOE-2 such as PowerDOE, and E-Quest, VisualDOE, DOE-2.1e. ***Equivalent programs may be used with permission, provided they are submitted for approval prior to use.***

The outputs of the energy model should provide information on Building Energy Consumption per End Use (BEPU) and the Energy Cost Summary (ES-D or ES-E). For a definition of these items, see the documentation section of Energy Prerequisite 4 – Performance Approach.

Audit Requirements

See audit requirements for EP 4 –Performance Approach. The audit documentation is the same.

Resources

CHPS *Best Practices Manual*, Volume II: Guideline OS1: Photovoltaics.

LEED™ *Reference Guide*: Energy and Atmosphere Credit 2: Renewable Energy.

For more information on the Massachusetts Renewable Energy Portfolio Standard, see www.mass.gov/doer/programs/renew/rps.htm.

See www.mass.gov/dte/cmr/220cmr1100.pdf for the regulations governing net metering.

For information on renewable electric energy grants, contact the Massachusetts Technology Collaborative or visit www.masstech.org.

ENERGY TRACKING

CREDIT 4.1: ENERGY MANAGEMENT SYSTEMS
CREDIT 4.2: SUBMETERING

1 point	EC 4.1. Install an energy management system (EMS) to monitor and trend the energy consumed by the following systems throughout the school. • HVAC (heating, cooling, fans) • Hot water systems Ensure that the system has the following attributes: Sensors (as defined below), points matrix, trend capabilities, system architecture (as defined below), data storage, and operator interface (as defined below). Provide a plan addressing trendlogging, operator training, and data analysis as detailed in the documentation requirements for this credit. The plan should explain how the collected data will be used to improve building operation as related to energy efficiency.
1 point	EC 4.2. In addition, install a submetering system for lighting loads and plug loads. Integrate the data collected from the submetering systems with the energy management system. Provide a plan explaining how submetered data will be used to improve energy system management. The plan may be included as part of the documentation required for the above credit.

While energy management systems (EMS) are typically installed with new HVAC and heating systems, care must be taken to specify and install an appropriate system for the district and its maintenance staff. The best EMS for a district is the simplest system that still addresses the school's energy management needs. Increased complexity does not always mean increased value for the district.

Energy management systems can potentially save significant energy, but only if the staff understands how to operate them. With EMS installation, proper training of district staff is absolutely critical. The district must be prepared to budget for staff training and for training new staff when those knowledgeable about the EMS leave employment.

Monitoring capabilities of the EMS should allow for comparison between various types of building loads throughout all spaces of the school. This information is valuable and can be used to manage and optimize energy use. By trending and monitoring the building operation, any deviation from the design operation can be identified and corrected before an impact on occupant comfort and energy performance of the building is created. Building performance can also be optimized by longer-term trending, observation of performance characteristics, and benchmarking performance against expected operation.

The EMS should comprise the following:

1. Sensors should be provided as follows:
   - Sensors to trend outdoor air temperature.
   - Sensors to monitor and trend equipment status for all equipment with motors greater than ½ hp.
   - Indication and trending of damper and valve commanded position.
   - Sensors to monitor building electrical, natural gas, and heating oil demand and consumption.
   - Sensors to monitor indoor and outdoor CO_2.

Sensors to monitor and *trend* (create trend logs) controlled variables at the operator interface. Control variables may include air and/or water flow, temperature, pressure, CO_2, and pump or fan speed. Relevant multiplexed data from microprocessors located in chillers, boilers, humidifiers, VAV box controllers, variable speed drives, and other HVAC equipment with multiplexing capabilities may be used in lieu of specifying separate sensors.

Wells and other ports shall be specified for the installation of calibration devices to facilitate calibration of sensors.

Exceptions:

- Unit heaters, cabinet heaters, radiation and convectors located in vestibules, storage rooms, janitor closets, and other unoccupied areas.
- Natural gas and heating oil demand sensors are not required on buildings less than 50,000 ft2.

2. Points Matrix: A points matrix including all hardwired input and output devices connected to the automation system, all set points, upper and lower control limits.
3. Trend Capabilities: Trend requirements including a trend point list and preprogrammed sample of point (performed by controls contractor), sample rate, storage interval, upload interval, custom trend abilities, alarms, and automated trend data review and notification (automated diagnostics).
4. System Architecture: A system architecture capable of allowing sampling of these points to facilitate building commissioning and diagnostics without significantly affecting system performance.
5. Data Storage: A data storage system with adequate capacity to record trend data for use by building operators. Data export requirements must facilitate user-friendly data access and manipulation.
6. Operator Interface: An operator interface designed for remote/web access, monitoring requirements, trend-log reporting and diagnosing building problems through a user-friendly interface. This includes providing a visual (non-text based) operations and reporting interface to facilitate rapid system assessment that utilizes color coding, diagrams of floor plans and graphing capabilities.

Source: Advanced Buildings Benchmark Version 1.1, by the New Buildings Institute, Inc. pp. 38–39.

Michael E. Capuano Early Childhood Center—Somerville
All major electrical, natural gas and water systems within the building are submetered. The purpose of the submetering system is: (1) to provide a basic understanding of the amount of natural gas, electricity and water used in various building systems; (2) to confirm that systems are functioning as designed and modeled; (3) to provide a benchmark for each system's performance for maintenance staff; (4) to educate maintenance staff, teaching staff, and students regarding changes in energy demand; (5) to enable competitive energy conservation; (6) to provide input into the school's environmental curriculum; and (7) to provide input for the Building Management System.

Photo credit: HMFH Architects, Inc.

Documentation

Energy Management System

1. Reference EMS specification sections that show compliance with this requirement. Designate the CSI number, section, and page number. The specifications must identify end devices, control panels, control software, operator computer workstations, system graphics, third-party equipment interfaces, network communication media and communication protocols.
2. Letter of intent signed by the Superintendent or Assistant Superintendent and the facility department head explaining: (a) who will be trained on the EMS (b) who will do the training (c) what trendlogging data will be collected (d) plans for training the next EMS operator in case of staff turnover.
3. Copy of a plan for monitoring and taking action based on data collected. That is, a plan explaining how the data collected from the system will be used for improving the efficiency and maintenance of the HVAC and hot water systems over time, signed by the facility or maintenance department head.

Submetering

1. Provide a copy of the plan for monitoring lighting and plug loads and taking action based on data collected—signed by the facility or maintenance department head. This may be included as part of the EMS documentation requirements (#3 above).
2. Riser Diagram highlighting metering of systems.
3. Reference specification sections that show compliance with this credit on submetering. Designate the CSI number, section, and page number.

Audit Requirements EC 5.1

1. Provide the submittal for energy management system.

2. Provide a summary of operating protocols that include:

- What is being measured by the EMS
- How these items are being measured
- What the communication method is
- What the system accomplishes
- What features are incorporated to ensure energy efficiency
- Which facility building systems are integrated
- How alarms are reported

Audit Requirements EC 5.2

None.

Resources

New Buildings Institute, Advanced Buildings, E-Benchmark October 2003, Version 1.0

CHPS *Best Practices Manual*, Volume II: Guideline TC23: Adjustable Thermostats; Guideline TC24: EMS/DDC; Guideline EL4: Lighting Controls for Classrooms.

School Facilities Manual, Washington State Office of the Superintendent of Public Instruction, 4th Edition, March 2000, available online at: www.k12.wa.us/facilities/SFMANUAL/intro.pdf

Materials

Waste Reduction and Efficient Material Use

Purpose: Reduce the amount of construction and demolition (C&D) and occupant waste entering landfills and promote the efficient reuse of materials and buildings.

Prerequisite 1: Storage & Collection of Recyclables

Required	MP 1. The school building shall meet any local ordinances for recycling space, if such exist, and provide an easily accessible area that is dedicated to the separation, collection, and storage of materials for recycling, including—at a minimum—paper (white ledger and mixed), cardboard, glass, plastics, aluminum cans, and metals.

The Commonwealth of Massachusetts has banned the following materials from the solid waste stream: aluminum cans, white paper, corrugated cardboard, single polymer plastics, glass bottles, televisions and computer monitors. Therefore, designers should designate areas in the school where these materials can be handled and sorted. For sizing guidelines on spaces for storage and handling of recyclable material, see the California Integrated Waste Management Board's *Recycling Space Allocation Guide* —go to: www.ciwmb.ca.gov/publications/localasst/31000012.doc.

Early in the design phase, be sure to reserve space for recycling functions and show areas dedicated to the collection of recycled materials on floor plans. Consider the question of how recyclable materials will be collected and removed from classrooms, teachers' prep rooms, and offices. When recycling bins are used, they should be able to accommodate a 75% diversion rate (from normal waste basket contents) and be easily accessible to students and staff as well as custodial staff. Consider bin designs that allow for easy cleaning to avoid health issues.

For more advanced recycling programs that may include recycling of organic waste (food and soiled paper), and dry waste, consider the extra storage space needed and where to locate materials to prevent nuisances such as odors and fruit flies. (Note: The Williamstown Elementary School in Williamstown, MA has instituted a composting program. Children separate their lunch food waste and it is composted off-site.)

Documentation

1. Copy of Local Recycling Ordinance, if it exists.
2. Plans showing recycling collection area and storage bins or dumpsters.
3. Provide a description of how recyclable materials will be removed from classrooms, teachers' prep rooms, and offices, and how directions for separating recyclable materials will be communicated to teachers, students, and custodians.

Audit Requirements

None.

Resources

For more information about recycling in Massachusetts, see the Department of Environmental Protection's Web site: http://www.mass.gov/dep/recycle/recycle.htm

California Integrated Waste Management Board Recycling Space Allocation Guide at: http://www.ciwmb.ca.gov/publications/localasst/31000012.doc

PREREQUISITE 2: SITE WASTE MANAGEMENT, 75% DIVERSION

CREDIT 1: SITE WASTE MANAGEMENT, 90% DIVERSION

Required for Green Schools	MP 2. Recycle, reuse, and/or salvage at least 75% (by weight) of non-hazardous construction and demolition waste, not including land clearing and associated debris.
1 point	MC 1. Recycle, reuse, and/or salvage an additional 15% for a total of at least 90% (by weight) of non-hazardous construction and demolition waste, not including land clearing and associated debris.

The Massachusetts Department of Environmental Protection's (DEP) instituted a ban on asphalt paving, brick, concrete, metal and wood wastes from Massachusetts's landfills and incinerators. Prerequisite 2 encourages a reasonable percentage of 75% diversion of non-hazardous construction and demolition wastes from new construction and renovation projects. For an additional point, Credit 1 sets a slightly more ambitious but achievable diversion rate of 90%. To view the latest version of the DEP waste ban see: http://www.mass.gov/dep/recycle/laws/policies.htm#wastebans

Waste Management Plans

Successful salvage, recycling, and diversion of construction and demolition materials is usually the result of a well thought out waste management plan and on-site training for contractors and subcontractors. Develop and specify a waste management plan that identifies:

1. The diversion percentage goals for C&D wastes, e.g., 75% or 90%.
2. Deconstruction, salvage, and recycling/reuse strategies and processes, e.g., scheduling of different stages of deconstruction to best remove recyclable or salvageable materials intact.
3. Methods of on-site communication directing the contractors and sub-contractors about what, how, when, and where to recycle.
4. Documents needed to show waste diversion—e.g., weight tickets for all wastes removed from the site including recycled and salvaged materials.
5. A method for collecting all recycling and waste data and organizing for an audit of the achieved recycling rates on the project.

See the *Recycling Construction and Demolition Wastes, a Guide for Architects and Contractors*, www.architects.org/emplibrary/CD_Recycling_Guide.pdf, sponsored by the Boston Society of Architects, Associated General Contractors of Massachusetts, and MA Dept of Environmental Protection (DEP). The DEP provides sample waste management plans at this link: www.mass.gov/dep/recycle/files/wastplan.doc. The Vermont Waste Management Division also provides tips for handling C&D wastes: www.anr.state.vt.us/dec/wastediv/recycling/planning.htm.

In addition, there are successful C&D waste diversion pilot projects that can be reviewed on the DEP web site. See links below:

- Cambridge City Hall Annex, Cambridge, MA: www.mass.gov/dep/recycle/files/cdcmbrdg.doc
- Douglas School, Douglas, MA: www.mass.gov/dep/recycle/files/cddougls.doc
- MIT Media Lab, Cambridge, MA: www.mass.gov/dep/recycle/files/cdmit.doc

Compliance calculations for this credit must be based on weight. Many recycling and landfill facilities weigh incoming materials. Shipments that cannot be weighed can be estimated based on their volume and density.

Recycle Rate (%) = [Recycled Waste [Tons] / (Recycled Waste [Tons] + Garbage [Tons])] x 100

Note: DO NOT include materials classified as hazardous wastes in these calculations.

Documentation

Designate the CSI number, section, and page number that highlight compliance with this requirement. Specification must state a Construction Waste Management Plan will be completed by the general contractor and that it will detail the following components:

- The diversion percentage goals for C&D wastes, e.g., 75% or 90%.
- Deconstruction, salvage, and recycling/reuse strategies and processes, e.g., scheduling of different stages of deconstruction to best remove recyclable or salvageable materials intact.
- Methods of on-site communication directing the contractors and sub-contractors about what, when, how, and where to recycle.
- Documents needed to show waste diversion—e.g., weight tickets for all wastes removed from the site including recycled and salvaged materials. If items are removed, and no weight tickets are generated, be sure to document the materials and date, estimate the weight and volume of the materials, and add them into the overall total for waste and/or salvaged/recycled material removed from the site.
- A method for collecting all recycling and waste data and organizing it for an audit of the recycling rates on the project.

Note: Specifications must also state a target C&D recycling rate.

Audit Requirements (MP 2 & MC 1)

Summary of all the weight tickets collected for demolition and construction debris removal. The summary shall include the following information, by line item:

(1) Date of load disposal

(2) Name of facility to which debris was taken

(3) Ticket number

(4) Type of debris

(5) Number of loads, yards and total pounds for each line item

(6) Number of pounds recycled for each line item

(7) Percentage of material recycled for each line item

(8) Totals for each figure listed above.

For material that is removed from site, and does not generate a waste ticket, provide an estimate of the weight and volume of materials removed.

Resources

Recycling Construction and Demolition Wastes: A Guide for Architects and Contractors www.architects.org/emplibrary/CD_Recycling_Guide.pdf

LEED™ *Reference Guide*: Materials Credit 2: Construction Waste Management.

Massachusetts Department of Environmental Protection, Bureau of Waste Prevention, C&D Waste Prevention—. http://mass.gov/dep/recycle/reduce/managing.htm

BUILDING REUSE

CREDIT 2.1: BUILDING REUSE 50%–95%

1-4 points	MC 2.1. Reuse large portions of existing structures during renovation or redevelopment projects. Maintain at least 50% of existing building structure and shell (exterior skin and framing, excluding window assemblies). Hazardous materials that are remediated as part of the project scope AND elements requiring replacement due to unsound material condition shall be excluded from the calculation of the percent maintained. Points are allocated as follows: • Maintain 50% of existing structure and shell – 1 point • Maintain 65% of existing structure and shell – 2 points • Maintain 80% of existing structure and shell – 3 points • Maintain 95% of existing structure and shell – 4 points

Reusing parts of the building can save significant money and resources, while greatly reducing the amount of construction waste. When materials are re-used, the environmental benefits start with resource savings and extend down through the entire lifecycle of the material: less energy is spent extracting, processing, and shipping the materials to the site. Depending on the amount of building reused, school districts can reduce their construction and material costs. However, the building envelope will significantly affect many important high performance areas, such as space programming, energy performance, opportunities for daylighting, and indoor air quality. In addition, care must be taken to ensure that any environmental hazards such as toxins, lead, and asbestos have been identified and their removal addressed.

Percentage of reused structural materials (foundation, slab on grade, beams, floor and roof decks, etc.) and shell materials (roof and exterior walls) should be estimated in square feet. Average together the structural and shell reuse percentages. The average will be used to determine the overall reuse percentage for the building.

Building Reuse (%) = 100 x [Reused (floor+ roof area + ground floor/slab) + Reused (exterior wall area excluding window assemblies)] ÷ [[Total (floor+ roof area + ground floor/slab) + Total (exterior wall area excluding window assemblies)].

Documentation

1. Demolition plans
2. Floor plans showing existing elements
3. Elevations showing existing and remaining elements.

Audit Requirements

1. Submit change orders for all design changes.
2. Submit a final schedule of values for payment.

Note: This credit will be subject to review if design changes are made affecting the amount of existing structure and shell that are retained.

Resources

LEED™ 2.2 *Reference Guide*: Materials Credit 1: Building Reuse.

CREDIT 2.2: BUILDING REUSE INTERIOR 50%

1 point	MC 2.2. Maintain 50% non-structural elements (walls, floor coverings, and ceiling systems).

Percentage of reused, non-shell building portions will be calculated as the total area (ft^2) of reused walls, floor covering, and ceiling systems, divided by the existing total area (ft^2) of walls, floor covering, and ceiling systems.

Internal Building Reuse (%) =

Reused Non -structural Elements [ft^2]/ Total Non-structural Elements [ft^2] x 100

Documentation

1. Demolition plans
2. Floor plans showing existing elements.
3. Elevations showing existing and remaining elements.

Audit Requirements

1. Submit change orders for all design changes.
2. Submit a final schedule of values for payment.

Resources

LEED™ 2.2 *Reference Guide*: Materials Credit 1: Building Reuse.

SUSTAINABLE MATERIALS

CREDIT 3: COMBINED MATERIALS ATTRIBUTES

1–7 points	MC 3. Record rapidly renewable, salvaged, recycled content, and certified wood materials attributes in a single materials credit. Up to 7 points are available.

"Combined attributes" is the term used to recognize the many facets of environmentally-friendly materials including recycled-content, salvaged , bio-based, and Forest Stewardship Council certified materials. The credit is designed to capture the value of environmentally-friendly materials even if modest amounts are specified for the school project. Materials specified for a school construction project may have more than one environmental attribute and this credit simplifies the process of claiming points for multiple attributes. A spreadsheet and instructions for this credit are found in the Application Template, which is a document created to organize submissions for green school certification.

To earn points, fill out the material cost information required in the spreadsheet found in the Application Template. Calculating a total materials budget can be difficult for projects where labor and materials costs are combined in the cost estimate. To navigate this difficulty, MA-CHPS uses the LEED method of deriving the materials' cost by assuming that it is 45% of the construction budget. MA-CHPS also makes the assumption that, *on average*, the cost of labor for each individual material installation is 65% of the cost. In the Application Template, insert the cost of each material with labor costs included.

Where the percentage total for the combined attributes is less than X.5, then the total should be rounded down to X. Where the credit total is greater than or equal to X.5, then round up to the next whole number. To see how this works, look at an example of a spreadsheet shown on the next page.

Categories of Environmentally-Friendly Materials

MA-CHPS recognizes four different categories of environmentally-friendly materials: salvaged, recycled content, bio-based, and Forest Stewardship Council certified wood content. In a separate credit, MA-CHPS also recognizes materials that are formulated to produce no or very low amounts of VOC's (Volatile Organic Compounds). See IEQ Credit 2.1 – Low Emitting Materials for more information on this topic.

Salvaged Material

Salvaged material is defined as material taken from another site and used for the same purpose at the new site, e.g. removing wood flooring from another site to use as flooring in the new school. Salvaged material may also come from the same building site but must be used for a different purpose, otherwise it is considered recycled material. For example, many schools build on the same site and demolish the old school building when the new one is completed. If the project demolished concrete structures from the old school and ground the concrete as fill for the new school, the concrete fill would be considered salvaged material. Commonly salvaged building materials include wood flooring/paneling/cabinets, doors and frames, mantels, ironwork and decorative lighting fixtures, brick, masonry, and heavy timbers.

Recycled Content Materials

The number and variety of products containing recycled material expands every year. Using these materials creates markets for materials gathered through recycling programs across the country. It also reduces the extraction of virgin materials and the use of landfill space. Recycled-content alternatives exist for all major building materials and surfaces. Recycled content is defined as either post-consumer (collected from end users) or post-industrial. Post-industrial material is collected from manufacturers and industry. Post-consumer recycled content is weighted more heavily under this credit.

Bio-Based Materials

Bio-based materials contain a significant amount of materials from natural fibers, plants stalks and leaves, and plant extractions. Ideally, these materials are grown sustainably and do not result in significant biodiversity loss, increased erosion, and air quality impacts; products in this category include bamboo products, wheat grass cabinetry, linoleum and other natural materials. Wood-based materials do not receive points in this category.

Certified Wood

The Forest Stewardship Council (FSC) has developed guidelines for the sustainable harvest of wood. FSC works with landowners and lumber companies to ensure that sustainable forestry is practiced, and they accredit independent organizations to certify that these practices are met. The independent organizations also verify that suppliers of FSC wood have chain of custody certification to ensure that the wood they sell can be tracked back to an FSC certified forest.

Wood products bearing the FSC label come from forests that are managed in environmentally responsible, socially beneficial, and economically viable ways. For more information about certified wood and where it can be purchased, see: www.fscus.org

Table 10—Sample Materials Attributes Calculation Spreadsheet

Note that bio-based and salvaged materials are not included due to lack of space.

Materials (by CSI category)	Type of Material with Attribute	$ Value of Material	Post-Consumer Recycled Material			Post-Industrial Recycled Materials			Forest Stewardship Certified Wood			% Total Cost
Division 6—WOOD AND PLASTICS												
Finish Carpentry	Wood	$2,300		0.2	0.00%		0.1	0.00%	100%	0.6	0.14%	0.14%
Architectural Millwork	Wood	$28,100		0.2	0.00%		0.1	0.00%	50%	0.6	0.84%	0.84%
Architectural Casework	Wood	$10,000		0.2	0.00%		0.1	0.00%	50%	0.6	0.30%	0.30%
Division 7—THERMAL & MOISTURE												
Metal Roofing Metal Wall Panels	Aluminum	$20,000	85%	0.03	0.05%		0.03	0.00%		0.6	0.00%	0.05%
Division 8—DOORS AND WINDOWS												
Doors	Steel	$12,800	85%	0.03	0.03%		0.03	0.00%		0.6	0.00%	0.03%
Doors	Wood	$5,000		0.03	0.00%		0.03	0.00%	100%	0.6	0.30%	0.30%
Windows	Aluminum	$5,000	95%	0.2	0.10%		0.1	0.00%		0.6	0.00%	0.10%
Windows	Wood	$5,000		0.2	0.00%		0.1	0.00%	100%	0.6	0.30%	0.30%
Division 9—FINISHES												
Gypsum Wallboard	Gypsum	$20,500		0.2	0.00%	28%	0.1	0.06%		0.6	0.00%	0.06%
Acoustical Ceiling Tiles	Mineral Fiber	$5,000	100%	0.2	0.10%		0.1	0.00%		0.6	0.00%	0.10%
Acoustical Ceiling Tracks	Steel	$5,000	85%	0.03	0.01%	75%	0.03	0.01%		0.6	0.00%	0.03%
	Total:	$118,700			0.30%			0.07%			1.88%	2.25%

Total MA-CHPS points achieved: The 2.25% total achieves a total of 2 points.

Documentation

Fill out the Application Template for Materials Credit 3. The total value of all the attributes, i.e., the total percentage summed at the lower right of the template, is the amount of credit that can be received. One to seven points may be achieved under this credit.

For each material listed, designate the CSI number, section, and page number that highlight compliance with environmental attributes of the material. For example, if Forest Stewardship Council (FSC) certified wood is used for all casework on the project, provide the specification calling for the FSC wood in the casework, so that the claim on the template may be verified.

Salvaged material
Exclude all labor costs, all mechanical and electrical material costs, and project overhead and fees. If the cost of the salvaged or refurbished material is below market value, use replacement cost to estimate the material value; otherwise use actual cost to the project. Provide the specifications for the salvaged material. Designate the CSI number, section, and page number that highlight compliance with this requirement.

Recycled Materials
Reference specification sections. Designate the CSI number, section, and page number that highlight compliance with this requirement.

Bio-based Materials
Reference specification sections. Designate the CSI number, section, and page number that highlight compliance with this requirement.

Forest Stewardship Council Certified Wood
Reference specification sections. Designate the CSI number, section, and page number that highlight compliance with this requirement.

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Audit Requirements

Provide the following:

1. Submittals for all salvaged material.
2. Submittals for all recycled content materials and for all bio-based materials.
3. Submittals for all wood-based materials indicating those that are FSC certified purchases and those that are not.

Resources

Old to New: Design Guide, Salvaged Building Materials in New Construction, 3rd Edition (2002) www.gvrd.bc.ca/buildsmart/PDFS/oldtonewdesignguidesalvbuildmatinnewc.pdf

LEED™ *Reference Guide*: Materials Credit 3: Resource Reuse.

LEED™ *Reference Guide*: Materials Credit 4: Recycled Content.

State Agency Buy Recycled Campaign (SABRC) at http://www.ciwmb.ca.gov/BuyRecycled/StateAgency/

California Integrated Waste Management Board (CIWMB) Recycled-content Products Database: www.ciwmb.ca.gov/rcp

Forest Stewardship Council Web site at: www.fscus.org

LEED™ *Reference Guide*: Materials Credit 7: Certified Wood.

Indoor Environmental Quality

INDOOR AIR QUALITY PREREQUISITES

Maintaining a high level of indoor air quality positively impacts student and teacher performance, can reduce absenteeism, and avoid the potential for long and short-term health problems. Achieving excellent indoor air quality starts during construction with proper drainage of the site, careful siting of air intakes, protecting building materials from moisture, and protecting HVAC systems from dust and debris. Additional prerequisites require superior standards for fresh air ventilation, particularly ASHRAE ventilation standards, and air-cleansing filters in air intakes and return air ducts. Implementing all the prerequisites in this section will provide a foundation for providing clean, breathable air in your school.

PREREQUISITE 1: ASHRAE *STANDARD 62.1-2004* COMPLIANCE

Purpose: Achieve good indoor air quality to protect student and staff health and improve performance and attendance.

Required	IEQP 1. Meet the minimum ventilation rate requirements of ASHRAE Standard 62.1-2004, Ventilation for Acceptable Indoor Air Quality.

Critical to the health and performance of building occupants is the delivery of fresh air to occupied spaces. Studies of indoor air quality as affected by ventilation rates, temperature, and humidity in office environments consistently show increases in productivity, perceived comfort, and attendance when fresh air flow is increased. Temperature and humidity are thermal comforts, the perception of which is often influenced by individual comfort thresholds and ability to control a nearby thermostat. But fresh air and increased ventilation have the direct benefit of removing indoor pollutants out of the work space resulting in better health and improved attendance.

HVAC system design and operation are key to how, when, and where fresh air is delivered to a space. An effective design will introduce fresh air at comfortable temperatures and remove stale air from the breathing zone with a minimum of mixing between the two. Ventilation air delivery should avoid "dead" zones where air is not effectively removed and should avoid blowing excessively on occupants. Upon installation of the HVAC system, testing, adjusting, and balancing (TAB) is performed to ensure that the design air flow is achieved in occupied spaces and that supply air is introduced at the same rate (or slightly higher) than exhaust air. Commissioning of the TAB process is always recommended to achieve optimal performance.

ASHRAE Standard 62.1-2004 is a recommended minimum; projects are encouraged to increase ventilation rates as much as possible without compromising energy efficiency.

Documentation
Supply a letter signed by the project's professional engineer certifying that the standards of ASHRAE *Standard 62.1-2004* will be met on the project.

Audit Requirements
None.

Resources
ASHRAE *Standard 62.1-2004*

PREREQUISITE 2: SMACNA IAQ GUIDELINES

Required	IEQP 2. During construction meet the recommended Design Approaches of the Sheet Metal and Air Conditioning National Contractors Association (SMACNA) *IAQ Guideline for Occupied Buildings Under Construction*, 1995, Chapter 3. Note: this prerequisite applies to occupied renovation projects only.

Applicants shall implement containment procedures for dusts, gases, fumes, and other pollutants created as part of any planned construction, addition to, or renovation of a school building. Such containment procedures shall be consistent with the most current edition of the *IAQ Guidelines for Occupied Buildings Under Construction* published by SMACNA. All bids received for school construction or renovations shall include the cost of planning and execution of containment of construction pollutants consistent with the SMACNA guidelines. The plan shall include a complaint procedure and a system (bulletin, backpack letters, web site) for communicating information about procedures, protective measures, and construction schedules from the construction team to the building occupants.

Documentation
Reference specifications for an Indoor Air Quality Management Plan that will address SMACNA control measures for maintaining good indoor air quality on the job site. The specifications should indicate who is responsible for implementing the IAQ management plan, and the plan should address utilizing low Volatile Organic Compound (VOC) products, depressurizing work areas, improved housekeeping, scheduling of construction activity to lower impacts of IAQ on workers and building occupants, and the method of communication between construction team and building occupants regarding complaints, concerns, and predicted changes to IAQ. Designate the CSI number, section, and page number that highlight compliance with this requirement.

Audit Requirements

Provide photographs, taken at various times during construction, with a narrative for each photo describing compliance with SMACNA guidelines as follows:

- Construction areas in occupied buildings that were isolated from adjacent non-construction areas using temporary walls, plastic sheeting, or other vapor retarding barriers.
- Construction areas that were maintained at a negative air pressure to surrounding non-construction areas.
- Recirculating air ducts that were temporarily capped and sealed (appropriate filters may be used if nuisance particulates are the only contaminant of concern).
- Supply air systems that were operated with filters in place.

Resources
ASHRAE *Standard 62.1-2004*

Sheet Metal and Air Conditioning National Contractors Association (SMACNA) *IAQ Guideline for Occupied Buildings Under Construction*, 1995.

PREREQUISITE 3: CONSTRUCTION IAQ DUCT PROTECTION

Required	IEQP 3. During construction, seal HVAC supply and return openings to protect them from dust infiltration (e.g., from drywall installation or wood floor sanding). If installing a new duct system, follow SMACNA guidelines "Duct Cleanliness for New Construction Guidelines" according to **advanced** levels of cleanliness. Of specific importance are the following: • Specify that ductwork be sealed when transported to the construction site. • Store ductwork in clean, dry conditions and keep sealed while it is stored. • Wipe down internal surfaces of ductwork immediately prior to installation to remove dust. • Seal open ends on completed ductwork and overnight work-in-progress. • During installation, protect ductwork waiting to be installed with surface wrapping, etc.

This construction practice will improve indoor air quality by minimizing the amount of indoor pollutants that are distributed and retained by the surface materials and ventilation systems during construction.

Documentation

Read the SMACNA guidelines and reference specification sections for duct protection including specific references to SMACNA Duct Cleanliness Guidelines **Advanced** Levels. Designate the CSI number, section, and page number showing compliance with this requirement.

Audit Requirements

1. Provide photographs taken at various times during construction, with a narrative for each photo describing compliance with SMACNA Duct Cleanliness advanced levels.
2. Interim site visits shall verify construction practices.

Resources

Sheet Metal and Air Conditioning Contractors' National Association, Inc., Duct Cleanliness for New Construction Guidelines; SMACNA 2000 ©. See SMACNA website for electronic copy: http://www.smacna.org/technical/index.cfm?fuseaction=papers.

PREREQUISITE 4: POLLUTANT SOURCE CONTROL, OFF-GASSING

Required	IEQP 4. Where chemical use occurs, including housekeeping areas, chemical mixing areas, copying/print rooms, photolabs, and vocational spaces, use deck-to-deck partitions with dedicated outside exhaust at a rate of at least 0.50 cubic feet per minute per square foot, no air recirculation, and adequate make up air. These spaces must have negative air pressure, which is defined as an outside exhaust at a rate of at least 0.50 cubic feet per minute per square foot. The spaces must maintain a negative pressure of at least 5 Pa (0.02 inches of water gauge) to a minimum of 1 Pa (0.004 inches of water) compared to

	their immediate environment and when their doors are closed. In photolabs, specify table vents to draw chemical vapors away from the breathing zone of dark room users.

Design to physically isolate activities associated with chemical contaminants from other locations in the building, and provide dedicated exhaust systems to contain and remove chemical pollutants from source emitters at source locations. Eliminate or isolate high hazard areas and design all housekeeping chemical storage and mixing areas (central storage facilities and janitors closets) to allow for secure product storage. Design copier rooms with structural deck-to-deck partitions and dedicated outside exhaust systems.

Documentation

Provide a letter signed by a professional engineer explaining how the spaces stated in IEQ Prerequisite 5: Pollutant Source Control, Off Gassing are ventilated to maintain a 1–5 Pa negative pressure, compared to their immediate environment, and are exhausted at a rate of 0.50 cfm/ft^2.

Audit Requirements

None.

PREREQUISITE 5: WALK-OFF MATS

Required	IEQP 5. Provide a 2-part walk-off mat system for all high volume entryways to capture dirt, particulates, and moisture before they enter the building. Part one of the system is a drop through mat within the vestibule. Do not install drain pans and traps in the vestibule in order to avoid build up of moisture during summer months. Part two is to provide walk-off mats in the entranceway of a recommended length of 15 feet.

Particles tracked into the school on shoes are one of the chief sources of contamination of carpets and floors. Research shows that carpeting in schools can be a reservoir of pesticides, heavy metals, and soil tracked in on students' shoes.

The best way to keep the school free of dust, dirt, and contaminants is to prevent these unwanted items from entering the building in the first place. It is especially important to protect young school children since they are more likely to sit and play on classroom floors and be more directly exposed to contaminants.

Documentation

1. Reference specification sections for walk-off mats, and frames (if applicable). Designate the CSI number, section, and page number that highlight compliance with this requirement.
2. Reference plans that comply with this requirement. Highlight locations of walk-off mat systems and their **lengths at all high volume entrances.**

Audit Requirements

Verification will be made during site visit of walk-off mats at all high volume entrances.

PREREQUISITE 6: DRAINAGE

Required	IEQP 6. Design surface grades to slope away from the building and the building foundation to drain away rain water, snow melt, and HVAC condensate and to prevent ponding, pooling or otherwise saturating the building envelope or foundation. Rain leaders, or downspouts, must be directed to infiltration structures, on site storage, rain gardens, or

	daylight - provided that surface drainage moves water well away from the building and does not result in unintended ponding or pooling. Condensate removal systems that rely on gravity drainage are strongly preferred to systems that use pumps due to the reduced maintenance associated with gravity systems. Note: The project is prohibited from specifying HVAC systems that use evaporation drip pans for condensate removal.

Due to health risks associated mold and microbial growth and the damage caused to buildings by water infiltration, all surface grades, drainage systems, and HVAC condensate must be designed to move water away from buildings and their foundations.

Documentation

1. Site plan showing grading plan
2. Diagram of condensate system
3. Typical detail of condensate drains showing drain trap and gravity drainage system
4. For unit ventilator systems with air conditioning equipment, provide specification language expressly prohibiting evaporation trays.

Audit Requirements

None.

PREREQUISITE 7: IRRIGATION DESIGN

Required	IEQP 7. Irrigation systems must not spray on buildings.

Permanent irrigation systems that spray on buildings can cause structural damage and mold growth. Do not install irrigation systems in locations where they spray directly onto buildings.

Documentation

Plan of irrigation system showing that sprinkler ranges do not intersect with buildings.

Audit Requirements

None.

PREREQUISITE 8: MOLD PROTECTION

Required	IEQP 8. Building materials, especially gypsum wallboard, wood, porous insulation, paper, and fabric, should be kept dry to prevent the growth of mold and bacteria. Cover these materials to prevent rain damage, and if resting on the ground, use spacers to allow air to circulate between the ground and the materials. Water damaged materials should be dried within 24 hours. Due to the possibility of mold and bacterial growth, materials that are damp or wet for more than 24 hours may need to be discarded. Immediately remove materials showing signs of mold and mildew, including any with moisture stains, from the site and properly dispose of them. Replace moldy materials with new, undamaged materials.

Construction activities can affect indoor air quality long after the building is occupied. Being careful to protect building materials from moisture and removing water-damaged materials are important practices in the prevention of mold growth in new buildings.

Documentation

Use specification language in Appendix D as sample language for your bid specifications. Reference specification sections for protection of building materials from water damage, and designate the CSI number, section, and page number that highlight compliance with this requirement.

Audit Requirements

Provide photographs taken at various times during construction, with a narrative for each photo describing techniques for protecting building materials from mold and moisture damage.

PREREQUISITE 9: ELECTRIC IGNITIONS FOR GAS-FIRED EQUIPMENT

Required	IEQP 9. Specify electric ignitions for the following gas-fired equipment – water heaters, boilers, air-handling units, and cooking stoves.

The purpose of this prerequisite is to prohibit standing pilot lights in gas-fired equipment. Under certain conditions, the accumulation of carbon monoxide from unlit pilot lights can cause dangerous air quality conditions for staff and students. Therefore, electric ignitions are required for the equipment listed in this prerequisite.

Documentation

Reference specification sections for gas-fired equipment that uses electric ignitions to light gas burners. Designate the CSI number, section, and page number that highlight compliance with this requirement.

Audit Requirements

None.

PREREQUISITE 10: AIR INTAKE LOCATION

Required	IEQP 10. Locate outside air intake openings a minimum of 25 feet from any hazard or noxious contaminants such as chimneys, plumbing vents, cooling towers, streets, alleys, parking lots, and loading docks. The distance between exhaust air or vent outlets and air intakes should the greater of 25 feet or the distance as determined by the Massachusetts State Building Code equation 2801.2.2.2. See reference to equation 2801.2.2.2 in Appendix E. Exception: When locating an air intake within 25 feet of a contaminant source is unavoidable, such opening shall be a minimum of 2 feet below the contaminant source and 10 feet horizontally from the nearest edge of the air intake to the nearest edge of the contaminant source. All intakes must be 6 feet above landscaped grade including soil, lawn, shrubs, or any plant life within 1.5 ft. horizontally of intake.

Locating air intakes away from sources of potential air pollution will ensure that indoor air quality is not compromised by diesel fumes or exhaust air from ventilation, kitchen, or HVAC systems. Be particularly careful to locate air intakes away from areas where school buses and other vehicles may be idling.

Documentation

Provide drawings showing all air intake openings. Clearly identify hazardous and noxious contaminant sources on the drawings and bubble each air intake with a 50 ft. diameter circle (25 ft. radius) on the drawings. In some cases, Massachusetts State Building Code equation 2801.2.2.2. will determine that the distance between exhaust air or vent outlets should be greater than 25 feet. In such instances, the greater distance is required. Indicate this variation on the drawings.

Where intake openings front on a street or public way, measure the horizontal distance from the centerline of the street or public way to the air intake.

If an air intake is within 25 ft. of vents, chimneys, plumbing vents, exhaust fans, cooling towers, streets, alleys, parking lots and loading docks, then show that it is at least 2 feet below the contaminant source and 10 feet away horizontally from the nearest edge of the air intake to the nearest edge of the contaminant source. Indicate the horizontal and vertical distances from the contaminant source in the drawings.

Audit Requirements

Verification shall be made during site visit of air intake locations and proximity to air contaminants including vehicle idling areas.

PREREQUISITE 11: DUCT LINERS

Required	IEQP 11. To maintain clean ducts and avoid particulate accumulation and/or mold in the ductwork, duct liners must meet the ASTM standards C 1071 and C 1104 for surface erosion resistance and water vapor sorption, respectively.

Duct insulation should be located on the outside of ductwork, unless it is being installed for the purpose of attenuating sound, and there is no other means of attenuation sound. Duct liners have been known to deteriorate over time and absorb moisture, leading to the release of particles in the ducts that can be blown into classrooms and offices. Ensure that the duct liners used for sound attenuation meet the ASTM standards for surface erosion resistance and water vapor sorption.

Documentation

Designate the CSI number, section, and page number that highlight the requirements for ASTM C 1071 and ASTM C 1104 for duct liners used throughout the HVAC system.

Audit Requirements

None.

PREREQUISITE 12: PROHIBIT FOSSIL-FUEL-BURNING EQUIPMENT INDOORS

Required	IEQP 12. Do not acquire fossil-fuel-powered machinery that is mobile and whose specific function is for use inside the building. This is to prevent accumulation of exhaust inside the building from equipment such as polishers and burnishers. This prerequisite does not include stationary equipment such as gas stoves, chemistry equipment, and vocational equipment.

Documentation
Provide a letter signed by the school superintendent stating that no indoor mobile fossil fuel burning equipment will be used in the new or renovated facility.

Audit Requirements
None.

PREREQUISITE 13: MINIMUM FILTER REQUIREMENTS FOR HVAC EQUIPMENT

Required	IEQP 13. Replace all HVAC filtration media immediately prior to occupancy. Filtration media shall have a Minimum Efficiency Reporting Value (MERV) of 10 except for unit ventilator systems, which shall have a MERV of 7. Note: If IEQ Credit 2.3 – Pollutant Source Control – requiring MERV 13 filters is fulfilled, then Prerequisite 14 is waived.

Documentation
Reference specification sections for replacement of filters with MERV 10 and, in unit ventilator systems, MERV 7. Designate the CSI number, section, and page number that highlight compliance with this requirement. Note: This documentation is unnecessary if IEQ Credit 2.3: Pollutant Source Control, High Efficiency Filters for MERV 13 filters is fulfilled.

Audit Requirements
1. Submit a list of all air handling units, roof top units, unit ventilators, etc. and the rating of filters used for each piece of equipment.
2. Provide submittals for filters with a MERV 7 and/or MERV 10 efficiency rating for each unit.

THERMAL COMFORT

Purpose: To provide a high level of thermal comfort with individual teacher control of thermal, ventilation, and lighting systems to support optimum health, productivity, and comfort.

PREREQUISITE 14: ASHRAE *STANDARD 55-2004* COMPLIANCE

Required	IEQP 14. Comply with ASHRAE *Standard 55-2004* for thermal comfort standards within established ranges per climate zone. Note that winter humidification and summer dehumidification shall not be required.

Although this prerequisite exempts HVAC engineers from considering humidification and dehumidification systems, there are design choices such as direction of air supply and air supply velocity, which can affect the humidity levels experienced by occupants. When designing the layout of the HVAC system, keep humidity impacts in mind.

Documentation

Supply a letter signed by the project's professional engineer (P.E.) certifying that ASHRAE *Standard 55-2004* guidelines will be achieved and how they will be achieved.

Audit Requirements

None.

Resources

Sixth Edition of the Massachusetts Building Code, 780 CMR 1303.3.1

ASHRAE *Standard 55-2004*

Blackstone Valley Regional Vocational Technical High School—Upton. Displacement ventilation is being used as an efficient means of providing ventilation and dehumidification for interior spaces. The supply air will be delivered through floor or wall-mounted diffusers (see gray diffuser on right wall in picture), designed to deliver air at low velocity. Supply air will typically be 100% outside air.

DAYLIGHTING & VIEWS

PREREQUISITE 15: ACCESS TO VIEWS, 70%

Purpose: To improve student productivity through quality daylighting designs that minimize glare and direct sunlight penetration. To provide a connection between indoor spaces and the outdoor environment through the introduction of sunlight and views into the occupied areas of the building.

Required for Green Schools	IEQP 15. Provide direct line of sight to view glazing from 70% of the combined floor area of classrooms and administration areas. To qualify, a space shall have view glazing area equal to or greater than 7% of the floor area. View glazing shall be clear and only include window area above 2.5 ft and below 7.5 ft from the floor. The total width of view glazing shall be greater than 1% of the floor area. Exception: School buildings that share at least two sides with other buildings are exempted from this requirement.

To meet the requirements of this credit, use the spreadsheet provided under IEQ Prerequisite 1 in the Application Template. Input the floor area for each classroom and administrative area. If some spaces are identical, then list their square footage only once and indicate how many rooms are identical.

For each space, use the information below to determine how much of the floor area qualifies. Two considerations come into play: the view window area and the total width of the view windows in aggregate. Each of these limits how much of the floor area qualifies, as explained below:

- To determine the maximum qualifying floor area based on the view window area, divide the view window area by 7%.
- To determine the maximum qualifying floor area based on the width of the view windows, divide the total width of view windows by 1%.

For each space, the qualifying floor area is the lesser of (1) the total floor area, (2) the floor area based on view window square footage or (3) the floor area based on view window width. The spreadsheet will sum the qualifying areas for classrooms and administrative spaces and compare them to the total classroom and administrative floor area. If the percentage is 70% or greater, then the school qualifies, otherwise it does not. Please see the sample Q & A, provided on the next page, for clarification.

Example

Q

A new school has 30 like classrooms each with a floor area of 960 ft². Each classroom has view windows with a total area of 60 ft² and a total width of 9 ft. The school also has 6 larger 1,040 ft² classrooms with 70 ft² view windows with a total width of 10.5 ft. The 2,600 ft² multi-purpose room has 200 ft² of view windows with a total width of 25 ft. The 2,000 ft² administration area has 150 ft² of view windows with a total width of 18 ft. Does this school qualify for the view windows credit and how much of the floor area qualifies as having view windows?

A

The total floor area of classrooms, administration areas and the multi-purpose room is 39,640 ft² (see the table below). To qualify for this credit, at least 70% of the floor area of these spaces shall have view windows, or a total of 27,748 ft². The floor area must be determined for each space based on the total view window area and the total width of the view windows. For the smaller classrooms, the maximum floor area based on view window area is 857 ft² or 60 ft² divided by 7%. The maximum floor area based on window width is 900 ft or 9 ft divided by 1%. The qualifying area is the smaller of these numbers, or 857 ft². For the larger classrooms, the qualifying area is 1,000 ft², for the multi-purpose room it is 2,500 ft², and for the administration areas, it is 1,800 ft². The total qualifying area is 36,010 ft² or 91%. See the table below for details of the calculation.

Space	Size (ft²)	Number of spaces	Total area (ft²)	View window area (ft²)	Maximum Floor Area based on view window area (ft²)	Total width of view windows (ft)	Maximum floor area based on view window width	Qualifying floor area per space (ft²)	Total qualifying floor area (ft²)
Classroom Type 1	960	30	28,800	60	857	9	900	857	25,710
Classroom Type 2	1040	6	6,240	70	1,000	10.5	1,050	1000	6,000
Multi-Purpose Room	2600	1	2,600	200	2,857	25	2,500	2500	2,500
Admin-istration Area	2000	1	2,000	150	2,142	18	1,800	1800	1,800
Totals			39,640						36,010
								Percent Qualifies:	91%

Documentation

1. Submit the "Access to Views" spreadsheet in the applications template. To complete this spreadsheet, you will need the square footage of each classroom and administrative space, the square footage of view windows per space, and the width of the view windows (added together for each space). Identical spaces may be listed just once. An identical space is one with the same physical configuration, including windows.
   The template will divide the area of view windows by 7% and the width of the view windows by 1%. The template will automatically select the lower value of the two figures and create a sum based on the number of rooms with the same dimensions. Once all the data have been input into the spreadsheet, the template will calculate whether the view space meets the 70% threshold. The same process is used for Credit 1.1: Access to Views 90%, where view access must meet a 90% threshold in order to obtain credit. For the purposes of this credit, the following rooms are included:
   - General classrooms
   - Art rooms
   - Music rooms
   - Science rooms
   - Computer rooms
   - Special needs, remedial, and collaborative space
   - Administration spaces
2. Provide drawings of each floor. Classroom and administrative spaces need to be labeled to so that their names on the drawings match their names as input into the template.

Audit Requirements
None.

CREDIT 1.1: ACCESS TO VIEWS 90%

2 points	IEQC 1.1. Provide direct line of sight to view glazing from 90% of the combined floor area of classrooms and administration areas. To qualify, a space shall have view glazing equal to or greater than 7% of the floor area. View glazing shall be clear and only include window area above 2.5 ft and below 7.5 ft from the floor. The total width of view glazing shall be greater than 1% of the floor area.

Documentation
The documentation requirements are exactly the same as IEQ Prerequisite 15: Access to Views, 70%, with the exception that the threshold for this credit is 90% access to views. See IEQ Prerequisite 15 for information on preparing the calculations for this credit.

Typical classroom in the Holten-Richmond Middle School in Danvers, MA

Audit Requirements
None.

Resources
LEED™ *Reference Guide*: Indoor Environmental Quality Credit 8: Daylighting.

CREDIT 1.2: DAYLIGHTING IN CLASSROOMS

1-3 points	IEQC 1.2. Design spaces to optimize daylight while avoiding glare. All daylighting designs must adhere to the following requirements: • Given the geometry of the classroom and with consideration of site obstructions, fixed exterior shading, interior light shelves, and/or fixed blinds or louvers located between glazing, no direct sun can strike the teaching surfaces or a work plane located 4 ft. or more inside from the exterior walls at 9:00AM, noon and 3:00PM on the summer solstice and 9:00AM, noon and 3:00PM on the equinox. • Skylights and roof monitors shall meet the requirements of no direct sun penetration as described above, unless they have diffusing devices. Select one of the two compliance paths, either the Single Point in Time Approach or the Daylight Factor Approach. For either approach, achieve uniform daylight levels at the work plane so the maximum to minimum light level ratio is no greater than 8:1, determined at grid points spaced no greater than 4 ft. by 4 ft., for a clear day at noon on the equinox. The work plane is located 30 inches above the floor. To calculate points for IEQ Credit 2.1, tally the square footage of classrooms that meet the daylighting requirements, and tally the total square footage of all the classrooms. Divide the square footage of the daylit classrooms by total square footage of all classrooms to achieve the percentage of daylit classrooms. For an example, see a sample calculation at end of this

credit.

Applicable classroom types include:

- General classrooms
- Art rooms
- Music rooms
- Science rooms
- Special needs, remedial, and collaborative space

Single Point in Time Approach

Achieve an average horizontal daylight illumination in each qualifying classroom of not less than 25 footcandles for a clear day at noon on the equinox. Illumination shall be calculated at the work plane located 30 inches above the floor.

1 Point	25% of classrooms are daylit to an average level of 25 footcandles
2 Points	50% of classrooms are daylit to an average level of 25 footcandles
3 Points	75% of classrooms are daylit to an average level of 25 footcandles
4 Points	100% of classrooms are daylit to an average level of 25 footcandles

OR

Daylight Factor Approach

Under this approach, a classroom is considered to be daylit if it has an average Daylight Factor of at least 2%, when measured across a 4 ft. by 4 ft. grid using a physical model or a point by point calculation under overcast (CIE) skies. Illumination shall be calculated at the work plane located 30 inches above the floor.

1 Point	25% of classrooms are daylit (have average 2% or more Daylight Factor)
2 Points	50% of classrooms are daylit (have average 2% or more Daylight Factor)
3 Points	75% of classrooms are daylit (have average 2% or more Daylight Factor)
4 Points	100% of classrooms are daylit (have average 2% or more Daylight Factor)

The purpose of this credit is to encourage daylighting strategies in classrooms that also address glare control. The quality of daylight is just as important, if not more so, than the quantity of daylight in a classroom space.

William F. Stanley Elementary School—Waltham
A large skylight brings natural light into the stairwell and creates an attractive and comfortable environment for students and teachers. Photo credit:: Flansburgh Associates and photographer Mark Friedman

In addition to using design strategies such as light shelves, clerestory windows, roof monitors and skylights, classroom space configuration is also very important for access to daylight. This credit encourages designers to increase the length of the window wall in classrooms. For example, for a roughly 1,000 ft^2 classroom, it is preferable to design 30 ft. x 33 ft. classroom with 33 ft. running along the window wall. Previous architectural practice tended to make classrooms deeper, such as 24 ft. x 42 ft., with only 24 linear feet along the window wall.

Anecdotal evidence suggests a positive relationship between student performance and access to daylight. In fact, studies of office and retail environments show positive correlations between daylighting and increased productivity and sales, respectively. There is also growing evidence that daylighting positively impacts circadian rhythms, playing an important role in regulating sleep patterns.

Left: Translucent panels have been installed in several locations in the new Ashland High School in Ashland, MA.. The panels will allow increased natural light to enter these spaces. Top: Michael E. Capuano Early Childhood Center—Somerville. Clerestory windows and light shelves allow natural light to penetrate deeper into classroom spaces. Photo credit: HMFH Architects, Inc.

Documentation

1. Verify the requirement to avoid direct sun on teaching surfaces or the work plane located 4 ft. or more inside the exterior walls at 9:00AM, noon and 3:00PM on the summer solstice and the at 9:00AM, noon and 3:00PM on the equinox. One of the following verification methods can be used:
   - A physical model can be placed on a heliodon or otherwise positioned so that the sun angles represent the dates and times mentioned above.
   - A model may be set up in a computer based tool that can calculate sunlight on interior surfaces.
   - Sun profile angles can be manually calculated to show that the criteria are satisfied for the dates and times mentioned above.

2. Designate on drawings or designate the CSI number, section, and page number showing compliance with the requirement to provide diffusing devices for skylights and roof monitors.

3. Submit calculations to support points claimed for daylighting. Follow directions for either the Single Point in Time Approach or the Daylight Factor Approach.

   For the Single Point in Time Approach, create a computer model or physical model to substantiate the amount of square footage that is considered daylit.

   Single Point in Time Approach – Computer Simulation

   Computer simulation tools include Lumen Micro, AGI32, Radiance, Lightscape, SPOT, Daysim, or equivalent software. A minimum analysis grid of 4 ft. by 4 ft. shall be used. The grid shall be positioned so that no analysis points are located closer than 4 ft. to a glazed wall. The average illumination and uniformity calculations should then be performed for the equinox at noon.

   Single Point in Time Approach – Physical Modeling

   If a physical model is used, the model should be constructed at a minimum scale of ½ in. equals one foot and care should be taken to use interior materials that have the same reflectance as the materials specified for the classroom. Glass or other material should be used in the openings that have the same light transmission as the fenestration proposed for the classroom. The model shall

be positioned outdoors on a clear day such that the solar angles for noon on the equinox are achieved.

Alternatively, for the Daylight Factor Approach, create a computer model or physical model to substantiate the amount of square footage that is considered daylit. The Daylight Factor shall be calculated for all typical classrooms at a minimum 4 ft. x 4 ft. analysis grid. The Daylight Factor for each classroom shall be the average of the grid points within the classroom.

Daylight Factor Approach – Computer Simulation

Computer simulation tools include Lumen Micro, AGI32, Radiance, Lightscape, SPOT, Daysim, or equivalent software. A minimum analysis grid of 4 ft. by 4 ft. shall be used. The average illumination and uniformity calculations shall then be performed for the equinox at noon. The uniformity calculations shall be performed under clear sky conditions. Calculations for illumination (daylight factor) shall be performed for overcast (CIE) sky conditions.

Daylight Factor Approach – Physical Model

If a physical model is used, the model should be constructed at a minimum scale of ½ in. equals one foot and care should be taken to use interior materials that have the same reflectance as the materials specified for the classroom. Glass or other material should be used in the openings that have the same light transmission as the fenestration proposed for the classroom. The model shall be placed in an artificial sky calibrated to overcast (CIE) sky conditions.

Note: For either compliance approach, if the maximum to minimum footcandle ratio in a classroom is greater than 8:1 outside of the 4 feet closest to the exterior walls, then the entire square footage of the classroom is considered non-compliant.

Sample Calculation to Determine Points for IEQ Credit 2.1:

Assume that there are total 20 classrooms in a school. Ten classrooms have an area of 1,000 ft^2/classroom and ten classrooms have an area of 850 ft^2/classroom. Total square footage for all classrooms is (10*1,000 ft^2) + (10*850 ft^2) = 18,500 ft^2. Assume that 4 large classrooms and 2 small classrooms are daylit. That is, they have at least a 2% average Daylight Factor or an average 25 footcandle level **everywhere** beyond 4 ft. zone next to the window and meet the daylight uniformity and direct sun penetration requirements. Take the entire square footage of these daylit classrooms (4*1000 ft^2) + (2*850 ft^2) = 5700 ft^2 and divide by the square footage of all classrooms, which is 5700 ft^2/18,500 ft^2 and equal to 0.31 or 31%. Thirty-one percent qualifies for 1 point under either compliance approach.

Audit Requirements

None.

Resources

CHPS Best Practices Manual: Volume II: Daylighting and Fenestration Design Chapter.
LEED™ Reference Guide: Indoor Environmental Quality Credit 8
Advanced Lighting Guidelines: 2003 Edition: www.newbuildings.org/lighting.htm
AGI32 Lighting Design Software: www.agi32.com/
DAYSIM Daylighting Analysis Software: http://irc.nrc-cnrc.gc.ca/ie/lighting/daylight/daysim_e.html
DOE-2 Building Energy Use and Cost Analysis Software: http://doe2.com/
Ecotect: http://ecotect.com/
EnergyPlus Building Energy Simulation Program: http://gundog.lbl.gov/
Equest: www.doe2.com/equest
Lightscape: http://usa.autodesk.com

INDOOR ENVIRONMENTAL QUALITY CREDITS

CREDIT 2.1: LOW-EMITTING MATERIALS

1–4 points	IEQC 2.1- Specify materials that have been tested and certified for low emissions of volatile organic compounds (VOC's). One point is possible in each category, with a maximum of four points for this credit. • 50% of all adhesives, sealants, and concrete sealers by total submittals • All carpet systems and associated adhesives • All resilient flooring and associated adhesives • All paint that covers interior walls, floors, and ceilings • All building insulation (excluding insulation exterior to the building's vapor barrier) • All acoustical ceiling tiles or wall panels • All wood flooring • Composite wood boards • All cabinetry • All teacher/student desks and chairs • All gypsum wallboard Note: See table 11 for standards and certification programs that verify whether a product has low VOC's or not.

Many common indoor building and surfacing materials contain a variety of potentially carcinogenic and/or toxic chemicals. These chemicals are released into the air and can cause a variety of health problems, from minor irritation to major health problems. Because a single material can off-gas enough toxins to cause health problems, it is important to evaluate and specify materials that are low emitting, non-irritating, nontoxic, and chemically inert. This is especially important in schools because children are more sensitive to indoor air pollutants than adults.

The California Office of Environmental Health Hazard Assessment (OEHHA) has adopted health-based chronic reference exposure levels (CREL's) for 80 volatile organic compounds (VOC's). California standards are referenced because the federal government has not published chronic reference exposure levels for VOC's in indoor air. The most current list of California's CREL's was published in February 2005 and can be found at following website: http://www.oehha.ca.gov/air/chronic_rels/index.html or specifically at http://www.oehha.ca.gov/air/chronic_rels/AllChrels.html.

Technical note: Because background levels of formaldehyde detected in schools exceeded the California CREL's in most cases, the OEHHA developed an interim value for school children. Formaldehyde is acceptable at 27 ppb (33 µg/m3) as an 8-hour interim indoor reference exposure level (as opposed to the CREL of 3 µg/m3). Therefore, low VOC products may meet the 27 ppb of formaldehyde as an appropriate maximum 8 hour exposure level for school children.

There are three methods of identifying low VOC materials that meet this credit: Project designers and owners must first decide which categories of materials they will pursue for this credit. Once the categories have been selected, one or more of the following methods must be pursued: 1) Project designers can work with manufacturers to arrange for lab testing of materials to determine whether they meet the California CREL's; OR 2) project designers can specify three materials in the construction contract that have been certified by one of the programs listed below OR 3) project designers can specify three materials in the

construction contract that are listed on California CHPS website for low VOC compliant materials. See the CHPS low VOC compliance table at: http://www.chps.net/manual/lem_table.htm. Using any of the three methods will ensure that the California standards are met.

The following is a description of the low VOC certification programs and their weblinks, which are useful in identifying products that have already been tested to the California standards:

Scientific Certification Systems Website: www.scscertified.com/products/

- Indoor Advantage™ Gold - This program tests and certifies low VOC products such as adhesives, paints, insulation, acoustical ceiling tiles etc. See website: www.scscertified.com/iaq/indooradvantage.html#ia
- FloorScore™ – This program certifies low VOC resilient flooring and associated adhesives. See website: www.scscertified.com/iaq/floorscore_1.html

GreenGuard Environmental Institute Website: www.greenguard.org

- Children and Schools™ - GreenGuard's Children and Schools program certifies low VOC adhesives, resilient flooring, paints, insulation, acoustical ceiling tiles, and more. See website: www.greenguard.org/DesktopDefault.aspx?tabindex=4&tabid=95

Carpet and Rug Institute Website: www.carpet-rug.com

- Green Label Plus™ – The Green Label Plus™ program certifies low VOC carpet systems including carpet backing and adhesives. See website: www.carpet-rug.org/drill_down_2.cfm?page=8&sub=3&requesttimeout=350

Table 11 shows which certification programs are currently available for different categories of materials. As indicated by the second column, materials can be sent for testing at one of four independent laboratories. If this option is selected, the design team should contact the Massachusetts School Building Authority to identify appropriate lab testing facilities. Although not indicated below, the CHPS low VOC compliance table can be utilized to find low VOC materials for the project at: http://www.chps.net/manual/lem_table.htm.

Table 11 - Low-Emitting Materials - Standards and Certification Programs

Materials Category	Certification Standard Options (Choose One)		
Adhesives, sealants, and concrete sealers	California standards Independent testing	Indoor Advantage™- Gold	Children and Schools™
Carpet systems and associated adhesives	California standards Independent testing	Green Label Plus™	---
Resilient flooring and associated adhesives	California standards Independent testing	FloorScore™	Children and Schools™
Paint that covers interior walls, floors and ceilings	California standards Independent testing	Indoor Advantage™- Gold	Children and Schools™
All building insulation (excluding insulation exterior to the building's vapor barrier)	California standards Independent testing	Indoor Advantage™- Gold	Children and Schools™
Acoustical ceiling tiles or wall panels	California standards Independent testing	Indoor Advantage™- Gold	Children and Schools™
Wood flooring	California standards Independent testing	FloorScore™	Children and Schools™

Composite Wood Boards	California standards Independent testing	Indoor Advantage™- Gold	Children and Schools™
Cabinetry	California standards Independent testing	Indoor Advantage™- Gold	Children and Schools™
Teacher/Student Desks and Chairs	California standards Independent testing	Indoor Advantage™- Gold	Children and Schools™
Gypsum Wallboard	California standards Independent testing	Indoor Advantage™- Gold	Children and Schools™

Documentation:

Reference specification sections for all products that comply with the low VOC certifications above. Please designate the CSI number, section, and page number that highlight compliance with this requirement.

Audit Requirements

Submittals for all low-emitting materials that were submitted for this credit, the submittals must match the specifications. If substitutions are made during construction, ensure that the submittals show that the substitute materials meet the low VOC criteria.

Resources

Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers, by the California Department of Health Services.

To access more information about chronic exposure reference levels (CREL's) posted by California's Office of Environmental Health Hazards Assessment, call or write:

Office of Environmental Health Hazards Assessment
c/o California Environmental Protection Agency
1515 Clay Street
16th Floor
Oakland, CA 94612
Phone: (510) 622-3200

CREDIT 2.2: POLLUTANT SOURCE CONTROL, DUCTED HVAC RETURNS

1 point	IEQC 2.2. Install ducted HVAC returns to avoid dust and microbial growth issues.

Ceiling plenum returns are easily contaminated with dust and microbial growth. Ducted returns help prevent such problems and reduce maintenance and repairs.

Documentation

Provide a letter signed by engineer verifying ducted HVAC returns will be installed.

Audit Requirements

None.

CREDIT 2.3: POLLUTANT SOURCE CONTROL, HIGH EFFICIENCY FILTERS

1 point	IEQC 2.3. Design the HVAC system with particle arrestance filtration rated at Minimum Efficiency Reporting Value (MERV) of 13 in all mechanical ventilation systems. Install new filters immediately prior to occupancy.

Filters rated at MERV 13 will ensure very good quality ventilation air by blocking minute particles and allergens. Note: MERV 13 filters do not fit into unit ventilators. Therefore, schools with unit ventilator systems will not qualify for this point. The pressure drop may be greater with MERV 13 filters versus filters with lower MERV ratings, and therefore, more energy may be required to draw air through these filters. There is often a trade off between incremental indoor air quality improvements and energy efficiency that design teams should bear in mind. This credit may be especially desirable in environments where outdoor air quality is a serious concern, for example near schools in close proximity to heavy traffic.

Documentation

Reference specification sections for MERV 13 filters in all HVAC air handling systems. Designate the CSI number, section, and page number that highlight compliance with this requirement.

Audit Requirements

Submittals for filters with a MERV 13 efficiency rating. Note: If this credit is attempted, documentation for IEQP 14 is waived.

CREDIT 2.4: CONSTRUCTION IAQ HEPA VACUUMING

1 point	IEQC 2.4. Vacuum carpeted and soft surfaces with a high-efficiency particulate air (HEPA) filter vacuum prior to substantial completion. For phased, occupied renovations, HEPA vacuum the carpet daily in occupied areas.

This construction practice will improve indoor air quality by minimizing the amount of indoor pollutants that are distributed and retained by the surface materials and ventilation systems during construction.

Documentation

1. Reference specifications for HEPA vacuuming of carpeted floors prior to full building occupancy. Designate the CSI number, section, and page number that highlight compliance with this requirement.
2. For phased, occupied renovations, submit a signed letter from the Superintendent stating that carpeting in occupied areas of the school will be HEPA vacuumed on a daily basis.

Audit Requirements

None.

CREDIT 2.5: CONSTRUCTION IAQ BUILDING FLUSHOUT

2 points	IEQC 2.5. Prior to flushout, filters must be replaced with at least Minimum Efficiency Reporting Value (MERV) 10 filters and replaced again after flushout with a minimum of MERV 10 filters. For unit ventilator systems, a minimum of MERV 7 filters must be installed and then replaced with MERV 7 filters after flushout. AND Flush out each space once all major finish materials have been installed on floors, wall, and ceilings. This includes all casework. At that time, each space may be flushed out separately and occupied once 3,500 ft^3 of outdoor air per ft^2 of floor area of the space has been delivered. The space may then be occupied provided that it is ventilated at a rate of 0.30 cfm/ ft^2 of outside air or the design minimum outside air rate, whichever is greater, a minimum of three hours prior to occupancy and during occupancy, until the total of 14,000 ft^3/ft^2 of outside air has been delivered to the space.

Flushouts are intended to remove odors and volatile organic compounds (VOCs) that accumulate during the construction process. Many highly volatile materials offgas most quickly within several weeks of manufacture and installation. Therefore, conducting a building flushout shortly after finished materials are installed is optimal for reducing student and staff exposure to VOCs.

Documentation

1. Reference specifications calling for installation of MERV 10 filtration media prior to building flushout and post flushout. MERV 7 filters are required for unit ventilators systems both prior and following building flushout. Designate the CSI number, section, and page number that highlight compliance with this requirement.

2. Provide calculations from the HVAC engineer showing a) the settings needed to provide 3500 ft^3/ft^2 of outside air to each space in the school; b) the amount of time the ventilation system needs to run for each space to reach the minimum threshold of 3500 ft^3/ft^2; c) the settings for delivering outside air at a rate of 0.30 cfm/ ft^2 of outside air or the design minimum outside air rate, whichever is greater; d) the amount of time the ventilation system needs to run for each space to reach the minimum threshold of 14,000 ft^3/ft^2.

Audit Requirements

Provide a letter signed by construction manager that a building flushout was conducted. The letter must include:

- The flushout schedule, stating start and finish dates.
- Zone description of defined areas for flushout.
- List of air handlers within each zone.
- Filter media used during and after completion of flush-out.

ACOUSTICS

Purpose: To design HVAC systems and classrooms to provide acoustic levels that do not interfere with student and teacher communication.

Student learning suffers in acoustically poor environments. Excess noise from exterior sources, loud HVAC systems, or nearby rooms can make it difficult, and sometimes impossible, for students and teachers to communicate.

Poor acoustics affect more children than just those with permanent hearing impairments. Children with learning disabilities, language impairments, or children who are English language learners are also adversely affected by poor acoustics. In addition, children in general do not have fully developed language and auditory skills making quality acoustics very important for learning.

School officials and designers are strongly encouraged to move beyond the prerequisite to achieve background noise levels of NC30 (Noise Criteria) for all classrooms (approximately equivalent to 35 dBA) and sound isolation standards recommended by ANSI (American National Standards Institute).

It may not be possible to reach NC30 with unit ventilator systems, so consider HVAC system options other than unit ventilators. If you do opt for unit ventilators, however, it is important to select quieter models that can operate at low speeds.

Whitman-Hanson

The Whitman-Hanson Regional High School was designed to achieve NC30 (35 dBA). Whitman-Hanson's acoustical consultants applied 5 - 7 ft long silencers in the main supply and return ducts at the connections to the units that control fan noise transmission down the ducts. They also used completely lined ductwork downstream of the terminal boxes as the primary noise control treatments. According to the consultants, "Together, the main duct silencers and the lining downstream of the terminal boxes are expected to be sufficient to attenuate fan noise below 35 dBA for even the spaces that are closest to the air handling units, where the noise level is typically highest." Sound attenuation strategies for other school projects may vary.

Important aspects of classroom acoustical design include isolation from exterior noise (wind loads, traffic, and loud outdoor activities), elimination of interior noise (from HVAC systems, foot traffic, and other classrooms), and the use of appropriate wall assembly, window systems, and interior surface materials to minimize sound propagation and reduce reverberation times in the classrooms. The most common sources of interior mechanical noise are the air conditioning and air-handling systems, including ducts, fans, compressors, condensers, and dampers. The selection, location, and isolation of this equipment should be reviewed to minimize its impact on sound-sensitive spaces within school facilities.

Note: The acoustic measures listed in this section are not suitable for the learning environment needed for hearing-impaired children, which requires even further enhancements of the acoustical environment. Refer to the American Speech-Language-Hearing Association for further guidance.

CREDIT 3.1: MINIMUM ACOUSTICAL PERFORMANCE

1 point	Classrooms must have: • NC40 (45 dba) maximum (unoccupied) background noise levels at any location where a student may be situated. • 0.6-second maximum (unoccupied) mid-frequency (average of 500, 1,000 and 2,000 Hz) reverberation times for classrooms with volumes of up to 10,000 ft^3; 0.7-second maximum (unoccupied) mid-frequency reverberation time for classrooms of 10,000 to 20,000 ft^3; consult ANSI S12.60-2002 standard for requirements with spaces larger than 20,000 ft^3.

For purposes of this prerequisite and the acoustics credits, classrooms are defined as:

- General classrooms
- Art rooms
- Music rooms
- Science rooms
- Computer rooms
- Special needs, remedial, and collaborative space

Documentation

Provide a report from a qualified acoustical consultant verifying that classrooms have been designed to meet the relevant requirements.

Audit Requirements

None.

Resources

National Clearinghouse for Educational Facilities: www.edfacilities.org/.

Acoustical Society of America: http://asa.aip.org/ and http://asa.aip.org/classroom/booklet.html

American National Standards Institute: www.ansi.org/

American Speech-Language-Hearing Association: http://www.asha.org

CREDIT 3.2, 3.3: IMPROVED ACOUSTICAL PERFORMANCE

CREDIT 3.4 NOISE POLLUTION REDUCTION

1 point	IEQC 3.2. In addition to IEQ credit 3.1, maximum (unoccupied) background noise levels in classrooms must be reduced to NC35 (40 dba).
2 points	IEQC 3.3. In addition to IEQ credit 3.1, maximum (unoccupied) background noise levels must be reduced to NC30 (35 dba).
1 point	IEQC 3.4. Design classrooms in accordance with the noise isolation requirements referenced in American National Standards Institute's (ANSI) classroom acoustics standard entitled, "Acoustical Performance Criteria, Design Requirements, and Guidelines for Schools" (ANSI S12.60-2002). Project designers may want to increase sound transmission class (STC) levels in exterior walls beyond the ANSI standard if local noise pollution from trains, highways, pedestrians, or industrial noise sources will degrade the interior learning environment.

The diagrams below are schematic representation of ANSI's noise isolation requirements. Effective space planning should be used to avoid conflicting adjacencies where possible. Please consult the full ANSI standard, S 12.60-2002, for other details.

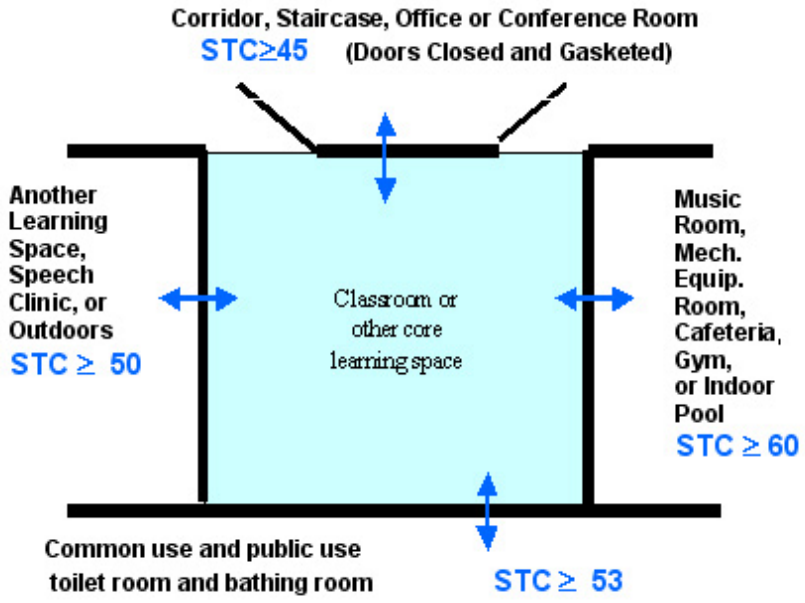

Figure 2— Noise Isolation (STC) Requirements (plan view)

Source: CHPS, Inc. PowerPoint presentation—modified based on requirements in ANSI S12.60-2002.

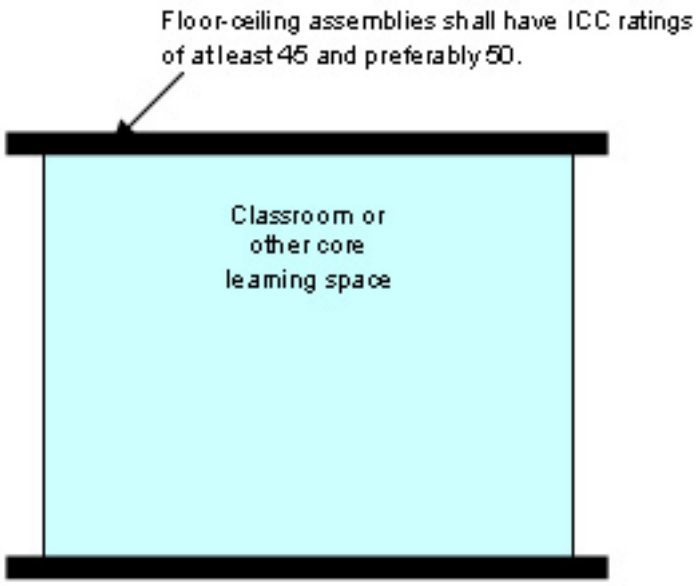

Figure 3— Impact Insulation Class (IIC) Rating (side view)

Source: CHPS, Inc. PowerPoint presentation—modified based on requirements in ANSI S12.60-2002.

Documentation

Provide a report from a qualified acoustical consultant verifying that classrooms have been designed to meet ANSI S12.60-2002 requirements.

Audit Requirements

No audit requirements for IEQC 3.1, 3.2, and 3.3. The following audit requirements pertain to IEQC 3.4.

1. Provide photographs taken at various times during construction, with a narrative for each photo describing compliance with credit guidelines, such as:
   - Sealing of penetrations in wall assemblies.
   - Lined ductwork for acoustical purposes.
   - Insulation installed.
2. Submittals for all door products; indicate sound transmission levels of doors.

Resources

National Clearinghouse for Educational Facilities: www.edfacilities.org/.

Acoustical Society of America: http://asa.aip.org/ and http://asa.aip.org/classroom/booklet.html

American National Standards Institute: www.ansi.org/

THERMAL COMFORT

CREDIT 4.1: CONTROLLABILITY OF SYSTEMS, WINDOWS

CREDIT 4.2: CONTROLLABILITY OF SYSTEMS, TEMPERATURE/LIGHTING

1 point	IEQC 4.1. Ninety percent (90%) of all classrooms shall have a minimum of one operable window per classroom that is reasonably accessible to the occupants, i.e., precludes use of ladders to adjust the window opening.
1 point	IEQC 4.2. Provide temperature and lighting controls for each classroom.

Operable windows are important for personal comfort, and have been shown to improve student performance. Provide at least one operable window in each classroom. Train teachers how to properly use the HVAC controls in their rooms and how opening doors and windows affects the HVAC system.

Individual classrooms will vary in temperature depending on their orientation, glazing apertures, occupancy, and the effectiveness of the heating or cooling systems. Provide individual systems to allow teachers to regulate the lighting and temperature of their classrooms.

Documentation

Operable Windows (IEQ Credit 4.1)

1. Reference specifications for operable windows. Designate the CSI number, section, and page number that highlight compliance with this requirement. For the purposes of this part of the credit, classrooms are:
    - General classrooms
    - Art rooms
    - Music rooms
    - Science rooms
    - Computer rooms
    - Special needs, remedial, and collaborative space

2. Submit floor plans with operable windows in each classroom highlighted.

3. Provide a brief narrative stating how many windows meet this requirement.

Temperature/Lighting Controls (IEQ Credit 4.2)

1. Submit specifications showing adjustable thermostats in the classroom types listed above.

2. Provide a narrative description of how occupants may control light levels in each classroom. Classrooms are defined as in the bulleted list above.

Audit Requirements

Verification shall be made during the site visit of operable windows in classrooms and temperature and lighting controls.

Policy & Operations

Purpose: To provide useful tools and ensure that the school continues to perform as designed. To protect student and staff health during occupancy. To specify energy efficient equipment to minimize energy loads and operational costs. To reduce emissions of district buses and other idling vehicles on school site. To recognize design teams and project owners for adopting innovative high performance features, greatly exceeding existing credits, or adopting significant policies that truly represent best practices in sustainability and/or environmental health and safety.

PREREQUISITE 1: MAINTENANCE PLAN

Required	The district must create a school maintenance plan that includes an inventory of all equipment in the new or renovated school and its preventive and routine maintenance needs. The inventory should cover the following systems: *Electrical Systems*: • Lighting controls (daylight, occupancy, timing switches, etc.); • On-site renewable solar electric or wind systems • Cable access television • Telecommunication Systems • Electrical distribution systems • Life and safety systems *Mechanical Systems*: • HVAC systems (such as hot water systems, chilled water systems, central air systems, ventilation systems); • Domestic hot water systems; • Energy Management System; • Renewable energy heating systems *Plumbing Systems:* • Flow control devices • Pumping systems

	• Special hazardous waste treatment systems (e.g. for lab wastes) • Domestic hot water systems • Graywater systems (if applicable) *AND* *Roofing systems* The plan must address the preventive and routine maintenance needed and include staff time and materials costs for each maintenance task and clearly define who is responsible for performing the task, as well as the overall management of maintenance activities.

Like conventional schools, all high performance schools and their systems require preventive and routine—not deferred—maintenance. This prerequisite encourages districts to plan for preventive and routine maintenance tasks and invest adequate funds in the maintenance of their school facilities.

The maintenance plan should include all regularly scheduled preventative and routine maintenance tasks and their frequency over the lifetime of the building system or equipment. These tasks include cleanings, calibrations, component replacements, and general inspections. Operations and maintenance manuals and commissioning reports developed during the commissioning process should be used as references for developing the maintenance plan. The plan must include staff time and materials costs for each maintenance task and clearly define who is responsible for performing the task, its frequency, as well as the overall management of maintenance activities.

Documentation

Submit a letter signed by the City or Town's project manager or school committee chair and the head of facilities outlining who will create the preventive maintenance plan and the inventory, how it will be done, and when it will be done.

Audit Requirements

1. Copy of inventory of building system (HVAC, lighting, renewable) components.

2. Preventive maintenance plan/report. The plan shall include the following information:

(1) Schedule of tasks, by week

(2) Frequency to perform task, i.e. weekly, monthly, bi-annually

(3) Priority ranking for each task

(4) Date task to be completed

(5) Personnel needed to carry out task

(6) Problems encountered and follow up tasks, if any

(7) Special training required to complete task, if any.

PREREQUISITE 2: ANTI-IDLING MEASURES

Required	Adopt a no idling policy that applies to all school buses operating in the school district and all vehicles operating in the school zone. The policy must include the following provisions: • School bus drivers will shut off bus engines upon reaching destination, and buses will not idle for more than five minutes while waiting for passengers. This rule applies to all bus use including daily route travel, field trips, and transportation to and from athletic events. School buses should not be restarted

	until they are ready to depart and there is a clear path to exit the pick-up area. • Post signage expressly prohibiting the idling of all vehicles for more than five minutes in the school zone. • District's schools will provide an indoor waiting space for drivers who arrive early and need to keep warm. • Transportation operations staff will evaluate and shorten bus routes whenever possible, particularly for older buses with the least effective emissions control. • All school district bus drivers will complete a "no idling" training session at least once. All bus drivers will receive a copy of the school district's No Idling Policy at the beginning of every school year. • Exceptions to this policy are appropriate only when running an engine is necessary to operate required safety equipment such as flashing lights or perform other functions that require engine-assisted power (e.g., waste hauling vehicles, handicap accessible vehicles etc.).

According to the U.S. Environmental Protection Agency (U.S. EPA), exposure to diesel exhaust, even at low levels, is a serious health hazard and can cause respiratory problems such as asthma and bronchitis. Diesel emissions are well-documented asthma triggers and may increase the severity of asthma attacks. Asthma is currently the leading cause of missed school days for American children, and asthma affects more than 1 in 9 children in New England. (Source: Asthma Regional Council - www.asthmaregionalcouncil.org/about/documents/SchoolBusNoIdlingPolicy7.29.04.doc).

Massachusetts's law prohibits vehicle idling for longer than five minutes with certain restrictions.

See M.G.L. Chapter 90, Section 16A, Stopped Motor Vehicles as written below:

> No person shall cause, suffer, allow or permit the unnecessary operation of the engine of a motor vehicle while said vehicle is stopped for a foreseeable period of time in excess of five minutes. The section shall not apply to (a) vehicles being serviced, provided that operation of the engine is essential to the proper repair thereof, or (b) vehicles engaged in the delivery or acceptance of goods, wares, or merchandise for which engine assisted power is necessary and substitute alternate means cannot be made available or (c) vehicles engaged in an operation for which the engine power is necessary for an associate power need other than movement and substitute alternate power means cannot be made available provided that such operation does not cause or contribute to a condition of air pollution. Whoever violates any provision of this section shall be punished by a fine of not more than one hundred dollars for the first offense, nor more than five hundred dollars for each succeeding offense.

The Massachusetts Department of Environmental Protection offers training to help school bus drivers and municipal employees eliminate unnecessary idling. See the following link for more information: http://www.mass.gov/dep/air/community/schbusir.htm. DEP also has a variety of tools available for school districts, including fact sheets, sample language for signage, sample newsletters, policy statements, information on bus routing software, and more. The Asthma Regional Council's Web site also offers a number of tools for the school district to use for its anti-idling program. See: www.asthmaregionalcouncil.org/about/BusToolkit.htm.

Documentation

Copy of signed resolution or signed school district policy including, at a minimum, the provisions outlined in this credit. See an example of a no-idling policy for school buses at the Asthma Regional Council web site: www.asthmaregionalcouncil.org/about/BusToolkit.htm.

Audit Requirements
1. Provide a copy of your school's anti-idling policy.

2. Provide submittals for anti-idling signage.

CREDIT 1: COMPUTERIZED MAINTENANCE MANAGEMENT SYSTEM

1 point	The school district shall purchase and use a computerized maintenance management system (CMMS) in the new or renovated school.

A Best Management Practice for preventive maintenance is a computerized maintenance management system (CMMS). Options exist for implementing a CMMS with stand-alone software or web-based services.

Documentation
Copy of signed contract for purchase of CMMS or receipt for purchase of CMMS.

Audit Requirements
None.

CREDIT 2: INDOOR ENVIRONMENTAL MANAGEMENT PLAN

1 point	Agree to implement the EPA's Tools for Schools Program or an equivalent indoor health & safety program for the new or renovated school. Designate a trained staff person as a point of contact for the EPA Tools for Schools program, or its equivalent.

EPA's Tools for Schools Program is designed to identify, address, and prevent indoor air quality problems in schools. It is well known that prevention and comprehensive planning for indoor air problems are far less costly to a school system than a crisis-reaction approach. The Tools for Schools kit provides a basic set of operations and maintenance guidelines that will help prevent IAQ problems in schools. It establishes responsibilities and clear communication channels so that indoor air problems can be prevented and problems can be quickly identified and solved. In addition, the Tools for Schools system can be used to address other environmental health and safety conditions that arise.

To learn more about Tools for Schools, contact the Region I U.S. Environmental Protection Agency New England office in Boston, Massachusetts—ph: (888) 372-7341 and seek further information at: www.epa.gov/iaq/schools/tools4s2.html.

Documentation
A resolution signed by the school committee or letter from the Superintendent declaring participation in U.S. EPA's Tools for Schools (or an equivalent program) for the school. Documentation must include the name of the designee who will be the point of contact for the Tools for Schools or equivalent program.

Audit Requirements
Participation in the Tools for Schools Program shall be verified by contacting EPA Tools for Schools Region 1 coordinator.

Resources
U.S. EPA: www.epa.gov/iaq/schools.

CREDIT 3: ENERGY STAR EQUIPMENT PERFORMANCE

1 point	The school committee must pass a resolution to require ENERGY STAR® equipment and appliances for all new purchases for the school and to prohibit the purchase of low efficiency products, including halogen torchieres and portable electrical resistance heaters.

The ENERGY STAR program maintains a database of compliant manufacturers and products. To earn this credit, the school committee must pass a resolution requiring that all new equipment or appliances purchased for the school must be ENERGY STAR-compliant. Products not currently covered under the ENERGY STAR program are excluded from the scope of this credit. A partial list of equipment covered by ENERGY STAR includes computers, monitors, copy machines, water coolers, printers, scanners, refrigerators, and washing machines.

The resolution must also state that the district cannot purchase halogen torchieres and portable electrical resistance heaters.

Documentation
Copy of the signed resolution passed by the School Committee, which meets the criteria above.

Audit Requirements
Provide an inventory list and submittals for all equipment and appliances indicating that they are Energy Star approved products.

Resources
ENERGY STAR: www.energystar.gov/.

CREDIT 4.1, 4.2: CLEAN ENERGY

1 point	Commit to purchasing Renewable Energy Certificates (REC's) equivalent to at least 50% of the school's projected annual regulated electricity needs.
1 point	Commit to purchasing Renewable Energy Certificates (REC's) equivalent to at least 100% of the school's projected annual regulated electricity needs.

School districts and municipalities now have the opportunity to purchase clean energy in the form of Renewable Energy Certificates, or REC's. For each megawatt-hour of power generated and supplied to the electric grid through renewable electricity generation (solar, wind, ocean thermal, wave, tidal, landfill gas and "low emission" bio-energy sources), a REC is issued to the market. The New England Power Pool (NEPOOL) monitors the number of REC's in the marketplace by keeping track of the amount of renewable electricity generated, the type of generation facilities, and the emissions characteristics of the generation facilities.

In Massachusetts, a renewable energy certificate can be classified as ***old*** or ***new***. ***New*** REC's, which qualify under the Massachusetts Renewable Portfolio Standard (RPS), come from renewable energy generation facilities built after 1997. ***Old*** REC's come from renewable energy sources built before 1997.

Once issued, REC's can be traded on the open market. Both ***new*** and ***old*** REC's can be purchased by retail electricity suppliers or renewable electricity suppliers for resale to customers. Consumers can purchase REC's through programs or companies across the country. When a consumer purchases REC's, the REC's are effectively retired and taken out of circulation, which contributes to the increased demand for generation and sale of additional renewable electricity.

In 1997, Massachusetts passed the Electric Utility Restructuring Act, which deregulated the electricity market and made the purchase of ***new*** clean energy more viable. Among other things, the law mandated that all electricity suppliers procure an increasing percentage of their electricity from a renewable energy facility generating ***new*** power. Since 1997, the demand for REC's that meet the Renewable Portfolio Standard requirements has increased sharply. This has led to an increased amount of ***new*** renewable energy generated in Massachusetts as well as an increased demand for the construction of renewable energy facilities across the Commonwealth.

An interesting characteristic of renewable energy certificates is that they can be purchased from any location in the country. However, purchasing REC's from local generation sources means that the environmental benefits are experienced locally. The Massachusetts Technology Collaborative (MTC) encourages the purchase of Massachusetts Renewable Portfolio Standard eligible REC's by offering matching grant programs. Check with the MTC to learn about current grant offerings and eligibility requirements (www.masstech.org)

To achieve this credit, purchase a block of megawatt-hours (MWh) of renewable electricity from a REC supplier or wholesaler. The REC's must be Massachusetts Renewable Portfolio Standard eligible. The block of kilowatt-hours purchased should equal 50% or 100% of the anticipated regulated electricity load of the school for one year of occupancy. The documentation section of this credit will explain methodology for calculating the building's regulated electricity load.

Documentation

Purchasing clean energy can be documented as indicated below.

1. If the project developed an energy model for Energy Prerequisite 4, then cite the regulated electricity load (in kWh) from the energy modeling report. Otherwise, an energy model must be developed to determine the school's regulated electricity loads. The following are acceptable energy modeling software programs: various versions of DOE-2 such as PowerDOE, and E-Quest, VisualDOE, DOE-2.1e. ***Equivalent programs may be used with permission, provided they are submitted for approval prior to use.***
2. Purchase enough blocks of REC's to offset at least 50% (for 1 credit) or 100% (for a second credit) of the school's annual regulated electricity load. The REC's must be Massachusetts Renewable Portfolio Standards eligible. Supply a receipt or copy of a renewable energy certificate to document proof of purchase.

Audit Requirements

None.

Resources

For more information on the Massachusetts Renewable Energy Portfolio Standard, see www.mass.gov/doer/programs/renew/rps.htm.

For more information on the Clean Energy Choice program, see www.masstech.org/.

Massachusetts Energy Consumers Alliance: www.massenergy.com/

U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, see: www.eere.energy.gov/greenpower/buying/buying_power.shtml?state=MA

CREDIT 5: INNOVATION

1–3 points	The innovation credits offer an opportunity to earn credits that follow in the spirit of the Massachusetts High Performance Green Schools program requirements. These points can also be garnered to reward efforts that greatly exceed the existing credit parameters. To achieve innovation points: 1) define the credit and its purpose; 2) describe the proposed criteria for compliance including any applicable standards; 3) identify and submit documentation that verifies compliance with the proposed credit; 4) submit a narrative describing how the credit reflects sustainable or environmental health and safety practices. OR If the innovation credit is for exceptional performance in an existing credit area, then submit a narrative of the design approach, which explains how credit was exceeded by a significant amount. Only one point may be applied to each innovation credit defined.

The MA-CHPS guidelines are designed to be a comprehensive guide to high performance green design, but as new technologies and creative designs evolve, there is a need to support and encourage them. These credits are also offered for communities that go beyond what is required by the guidelines and push to achieve superior performance, educational and environmental benefits, and excellent policies.

For examples of innovation credits, see the LEED NC 2.1 Reference Guide. As innovation credits are achieved in Massachusetts High Performance Green Schools projects, they will be made publicly available.

Ideas for innovation credits are listed below:

- Develop a comprehensive and innovative plan for using the sustainable aspects of the school as teaching tools.
- Implement an Environmental Management System for the school.
- Use Whole Building Life Cycle Cost Analysis for assessment of energy and HVAC systems and building materials.

Williamstown Elementary School—Williamstown, MA. Administrators and faculty have successfully used the new green school as a teaching tool for students – for example: green school principles are posted in every classroom, a green curriculum is facilitated by an environmental science mentor, each grade level has one or more green topics that link to the curriculum (the students share these topics with the community), students learn about energy and renewable power from the solar array on the school roof, students are also taught to recycle and compost their lunch waste. Photo credit: Margo Jones Architects, Inc.

Documentation

For each new credit attempted: 1) define the credit and its purpose; 2) describe the proposed criteria for compliance including any applicable standards; 3) identify documentation requirements that verify compliance with the proposed credit; 4) submit a narrative describing how the credit reflects sustainable or environmental health and safety practices, and 5) submit documentation identified in 3).

OR

If the Innovation credit is for exceptional performance in an existing credit area, then submit a narrative of the design approach, including an explanation of how the original credit was exceeded by a significant amount.

Audit Requirements

Audit documentation will be required on a case by case basis for innovation credits.

Glossary

ASHRAE—American Society for Heating, Refrigeration, and Air Conditioning Engineers.

ASTM—American Society for Testing and Materials.

B-20—B-20 is the term for a blend of 20% renewable bio-derived diesel fuel with 80% petroleum-based diesel fuel.

Biodiesel—Biodiesel is a domestic, renewable fuel for diesel engines derived from natural oils like soybean oil, and which meets the specifications of American Society for Testing and Materials D 6751. Biodiesel is not the same thing as raw vegetable oil. It is produced by a chemical process which removes the glycerin from the oil.

Bio-gas—Gas, rich in methane, which is produced by the fermentation of animal dung, human sewage or crop residues in an air-tight container. It is used as a fuel to heat stoves, lamps, run small machines and to generate electricity. The residues of biogas production can be used as a low-grade organic fertilizer.

Bio-oil—A liquid known as bio-oil can be created from biomass found in forestry and agricultural residues. The biomass is thermochemically converted to bio-oil by using processes called direct liquefaction or fast pyrolysis. The high water and oxygen content of bio-oils reduces their heating value to less than half the value of petroleum. However, bio-oils are low in viscosity and have been successfully burned in boilers, kilns, turbines and diesel engines.

Biomass—Biomass is any biological material that can be used as fuel. Biomass fuel is burned or converted in systems that produce heat, electricity, or both heat and power. In this document, biomass-fired systems refer to systems that are fueled by clean wood chips from forestry or saw mill operations.

CSI—Construction Specifications Institute

CHPS—Collaborative for High Performance Schools

ComCheck—This is software developed by the U.S. DOE to help commercial projects demonstrate compliance with all commercial energy code requirements for envelope, lighting, and mechanical systems. For more information, see: http://www.energycodes.gov/comcheck/

DOE-2—Software that was developed by the U.S. DOE to predict the fuel consumption (both electric and fossil fuel) of a building based on its design. Later iterations include DOE 2.2, a more advanced form of the original software.

DOE-2.1E—This is an updated version of DOE-2 software.

E-Quest—(Energy QUick ESTimator)—eQUEST is sophisticated software that allows for detailed energy analysis of a designed building. It also allows users to build 2-D and 3-D displays of the building geometry.

HEPA Filters – High Efficiency Particulate Air filters

PowerDOE—PowerDOE is another version of software that allows users to detail the predicted energy consumption of a building. Like e-QUEST, it is very graphical in its presentation of both the building description and the display of results. It includes 2-D and 3-D display of the building geometry.

VisualDOE—Energy modeling software that is based on DOE-2 and allows users to evaluate energy and demand impacts of design alternatives.

VOC—Volatile Organic Compounds

Appendix A

CEE High-Efficiency Commercial Air Conditioning and Heat Pumps High-Efficiency Specifications

Unitary Air Conditioners and Condensing Units, Electrically Operated

Equipment Type	Size Category	Sub-Category	Tier 2* Efficiency
Air Conditioners, Air Cooled (Cooling Mode)	<65,000 Btu/h	Split System	13.0 SEER 11.6 EER**
		Single Package	13.0 SEER 11.0 EER**
	≧65,000 Btu/hr and <135,000 Btu/hr	Split System and Single Package	11.0 EER 11.4 IPLV
	≧135,000 Btu/hr and <240,000 Btu/hr	Split System and Single Package	10.8 EER 11.2 IPLV
	≧240,000 Btu/hr	Split System and Single Package	10.0 EER 10.4 IPLV
Air Conditioners, Water and Evaporatively Cooled	All Sizes	Split System and Single Package	14.0 EER
		Split System and Single Package	14.0 EER
		Split System and Single Package	14.0 EER

SEER—Seasonal Energy Efficiency Ratio EER—Energy Efficiency Ratio IPLV—Integrated Part Load Value

**CEE Tier 1 was eliminated as of December 31, 2002 in response to increasing federal minimum standards.*

***CEE recognizes that SEER alone does not address demand savings, and encourages members to include measures that do. Use of this specification, while encouraged to promote continued improvement in demand performance, is at the discretion of participating utilities until such time as meaningful EER information is available for most potentially qualifying models.*

UNITARY AND APPLIED HEAT PUMPS, ELECTRICALLY OPERATED

Equipment Type	Size Category	Sub-Category	Tier 2* Efficiency
Air Cooled (Cooling Mode)	<65,000 Btu/h	Split System	13.0 SEER 11.6 EER**
		Single Package	13.0 SEER 11.0 EER**
	≧65,000 Btu/hr and<135,000 Btu/hr	Split System and Single Package	11.0 EER 11.4 IPLV
	≧135,000 Btu/hr and <240,000 Btu/hr	Split System and Single Package	10.8 EER 11.2 IPLV
	≧240,000 Btu/hr	Split System and Single Package	10.0 EER 10.4 IPLV
Air Cooled (Heating Mode)	<65,000 Btu/h	Split System	8.0 HSPF
		Single Package	7.5 HSPF
	≧65,000 Btu/hr and <135,000 Btu/hr	47˚F db/43˚F wb Outdoor Air	3.4 COP
		17˚F db/15˚F wb Outdoor Air	2.4 COP
	≧135,000 Btu/hr	47˚F db/43˚F wb Outdoor Air	3.3 COP
		17˚F db/15˚F wb Outdoor Air	2.2 COP
Water Source (Cooling Mode)	<135,000 Btu/hr	85˚ Entering Water	14.0 EER
Water Source (Heating Mode)	<135,000 Btu/hr	70˚ Entering Water	4.6 COP

SEER—Seasonal Energy Efficiency Ratio *EER—Energy Efficiency Ratio*

HSPF—Heating Seasonal Performance Factor *IPLV—Integrated Part Load Value*

COP—Coefficient of Performance

**CEE Tier 1 was eliminated as of December 31, 2002 in response to increasing federal minimum standards.*

***CEE recognizes that SEER alone does not address demand savings, and encourages members to include measures that do. Use of this specification, while encouraged to promote continued improvement in demand performance, is at the discretion of participating utilities until such time as meaningful EER information is available for most potentially qualifying models.*

Package Terminal Air Conditioners and Heat Pumps, Electrically Operated

Equipment Type	Size Category	Required Efficiency
Air Conditioners & Heat Pumps (Cooling Mode)	<7000 BTU/h	11.9 EER
	≧7000 BTU/h and <10,000 BTU/h	11.3 EER
	≧10,000 BTU/h and <13,000 BTU/h	10.7 EER
	≧13,000 BTU/h	9.5 EER

Source: Advanced Buildings—Benchmark Version 1.1

www.poweryourdesign.com/ABbenchmark.pdf -See Mechanical Equipment Efficiency Requirements—pp. 68-71.

Absorption Chillers

Equipment Type	Required Efficiency Full Load COP (IPLV)
Air Cooled, single effect	0.60, but only allowed in heat recovery applications
Water Cooled, single effect	0.70, but only allowed in heat recovery applications
Double effect—direct fired	1.0(1.05)
Double effect—indirect fired	1.20

Source: Advanced Buildings—Benchmark Version 1.1

www.poweryourdesign.com/ABbenchmark.pdf -See Mechanical Equipment Efficiency Requirements—pp. 68-71.

AIR AND WATER COOLED CHILLERS

Equipment Type	Size Category	Required Efficiency—chillers with ASDs or without ASDs		Required Efficiency—chillers with ASDs optional compliance path	
		Full Load (kW/ton)	IPLV (kW/ton)	Full Load (kW/ton)	IPLV (kW/ton)
Air Cooled w/ Condenser	All	1.2	1.0	N/A	N/A
Air Cooled w/o Condenser	All	1.08	1.08	N/A	N/A
Water-cooled Reciprocating	All	0.840	0.630	N/A	N/A
Water Cooled, Rotary Screw and Scroll	<100 tons	0.780	0.600	N/A	N/A
	≧100 tons and <150 tons	0.730	0.550	N/A	N/A
	≧150 tons and ≤300 tons	0.610	0.510	N/A	N/A
	>300 tons	0.600	0.490	N/A	N/A
Water Cooled, Centrifugal	<150 tons	0.610	0.620	0.630	0.400
	150 tons and ≤300 tons	0.590	0.560	0.600	0.400
	>300 tons and ≤600 tons	0.570	0.510	0.580	0.400
	>600 tons	0.550	0.510	0.550	0.400

Compliance with full load efficiency numbers and IPLV numbers are both required.

Systems with single chillers that operate on 460/480V require ASDs. ASDs are optional in multiple chiller systems.

Water-cooled centrifugal water-chilling packages that are not designed for operation at ARI Standard 550/590 test conditions (and thus cannot be tested to meet the requirements of this table) of 44ºF leaving chilled water temperature and 85ºF entering condenser water temperature shall meet the applicable full load and IPLV/NPLV requirements in Appendix B, Tables 1-6 of Advanced Buildings, E-Benchmark version 1.1.

Source: Advanced Buildings—Benchmark Version 1.1

www.poweryourdesign.com/ABbenchmark.pdf -See Mechanical Equipment Efficiency Requirements—pp. 68–71.

Appendix B

ENERGY MODELING METHODOLOGY

Modeling is only as good as the assumptions put into the model. This appendix provides guidance on energy modeling assumptions and refers to Energy Prerequisite 1 – Exceed Code by 20% and Energy Credit 1 – Superior Energy Performance. To determine energy savings between the base building and the as-designed building, building energy performance is determined using software tools typically based on the U.S. Department of Energy's software, DOE–2.

1. Energy savings calculations may be performed according to one of the following:

   - ASHRAE 90.1-1999 Section 11
   - ASHRAE 90.1-2001 Addendum e, Informative Appendix G Performance Rating Method

2. Only one method should be chosen and followed consistently throughout the calculations. If the same (identical) HVAC system type is used in the "As Designed" building and in the "Baseline" building (no credit is claimed for selecting a given system type), the selection of the baseline HVAC system does not need to follow the HVAC system mapping rules as described in:

   - ASHRAE 90.1-1999 paragraph 11.4.3 and shown in Figure 11.4.3 if ASHRAE 90.1-1999 Section 11 methodology is used in the energy savings calculations.
   - ASHRAE 90.1-2001 Addendum e, paragraph G4.2.1 and shown in Table G4.2.1A if Addendum e, Informative Appendix G Performance Rating Method is used for the energy savings calculations.

Appendix C

MINIMUM INSULATION REQUIREMENT R-VALUES AND MAXIMUM INSULATION U-FACTORS

For Climate Zone 5 including Massachusetts		
	R-Value	**U-Factor**
Roofs		
Insulation Entirely Above Deck	R-25 ci	U-0.039
Metal Buildings (with R-5 thermal blocks)[1]	R-19 □ + R-13	U-0.047
Attic and Other[2,3]	R-38	U-0.027
Walls Above Grade		
Mass, exterior insulation	R-11.5 ci	U-0.078
Mass, interior insulation	R-13	U-0.085
Metal Building	R-10 + R-13	U-0.061
Metal Framed	R-13 + R-5 ci	U-0.077
Wood Framed and Other	R-13 + R-3.8 ci	U-0.064

ci - continuous insulation

Source: Advanced Buildings – Benchmark v1.1 2005 pp. 54-55

[1] Thermal blocks are an R-5 of rigid insulation, which extends 1" beyond the width of the purlin on each side, perpendicular to the purlin.

[2] Where vapor permeable insulation is used, the temperature of any condensation plane should be kept above the dew point of the internal air.

[3] In any attic-type space, where insulation is blown or sprayed into the cavity, an additional R-11 of insulation is required.

Appendix D

PROTECTION OF BUILDING MATERIALS FROM WATER DAMAGE

SAMPLE SPECIFICATIONS FOR IEQ

Note: Coordinate this specification language with specification provisions elsewhere regarding protection of the Work and protection of materials from weather damage.

A. General: The General Contractor shall be responsible for protecting the Work from moisture, in order to prevent growth of fungus, bacteria and other biological contaminants.

B. Existing and New Building Construction:

1. Install weatherproof enclosures to protect the Work from exterior sources of moisture, in accordance with Division I specifications for materials and installation of weatherproof enclosures.

2. Remove and replace construction which has been wet for 24 hours or more, or which shows evidence of biological growth due to the presence of moisture.

C. Stored Construction Materials:

1. Store construction materials in clean, dry area to prevent porous materials such as gypsum board, insulation, ceiling tile, wood and similar products from becoming wet.

2. Discard construction material which becomes wet, or which shows evidence of biological growth due to the presence of moisture.

D. Procedures for drying out construction materials that have become wet:

1. In the case that an unanticipated event permits the entry of water into new or existing construction, the Contractor shall perform procedures to dry out construction within 24 hours. Restoration drying techniques shall be employed to achieve and maintain conditions that will not support biological growth. Consider the use of desiccant drying, which is a very effective way to prevent mold growth and accelerate drying of wet materials, including concrete.

2. Identify wet materials and remediate in accordance with the following publication: United States Environmental Protection Agency, 2001, “Mold Remediation in Schools and Commercial Buildings”. See: www.epa.gov/mold/mold_remediation.html or www.epa.gov/mold/images/moldremediation.pdf

3. Construction that is not adequately dried out, or which shows evidence of biological growth, shall be removed immediately from the construction area and disposed of legally.

4. Where construction has been in contact with contaminated water, subsequent cleaning and decontamination shall be supervised by a qualified company as approved by the Owner.

Appendix E

MASSACHUSETTS BUILDING CODE CITATIONS

The following is Massachusetts State Building Code language relating to measures listed in this section. To access the building code by the web, click here.

AIR BARRIER

The building envelope shall be designed and constructed with a continuous air barrier to control air leakage into, or out of the conditioned space. An air barrier shall also be provided for interior partitions between conditioned space and space designed to maintain temperature or humidity levels which differ from those in the conditioned space by more than 50% of the difference between the conditioned space and design ambient conditions. The air barrier shall have the following characteristics:

1. It must be continuous with all joints made airtight.
2. It shall have an air permeability not to exceed 0.004 cfm/ft2 under a pressure differential of 0.3 in. water (1.57 psf) (equal to 0.02 L/s/m2 @ 75 Pa.).
3. It shall be capable of withstanding positive and negative combined design wind, fan, and stack pressures on the envelope without damage or displacement, and shall transfer the load to the structure. It shall not displace adjacent materials under full load.
4. It shall be durable or maintainable.
5. The air barrier shall be joined in an airtight and flexible manner to the air barrier material of adjacent systems, allowing for the relative movement of systems due to thermal and moisture variations and creep. Connection shall be made between:
    - Foundation and walls
    - Walls and windows or doors
    - Different wall systems
    - Wall and roof
    - Wall and roof over unconditioned space
    - Walls, floor, and roof across construction, control, and expansion joints
    - Walls, floors, and roof to utility, pipe, and duct penetrations.
6. All penetrations of the air barrier and paths of air infiltration/exfiltration shall be made airtight.

Source: Massachusetts Building Code 780 CMR 1304.3

Slabs on Grade Insulation

The minimum thermal resistance (R-value) of the insulation around the perimeter of the slab floor on grade shall be R-5. The insulation shall be placed on the outside of the foundation or on the inside of the foundation wall. Insulation on the outside of the foundation wall shall extend downward from the top of the slab for a minimum of 48 in. Insulation on the inside of the foundation wall shall extend downward to at least the bottom of the slab and then horizontally for a minimum total distance of 48 in. In addition, the entire area of the slab on grade shall be insulated with a minimum of R-5 rigid insulation in the buildings of use group E, including daycare; buildings of use groups R-1, R-2, I-1, and I-2 and; college and university buildings of B and A use groups.

Exception: For a monolithic slab on grade floor, the insulation shall extend from the top of the slab on grade to the bottom of the footing. Continuous under-slab insulation shall be provided per 1304.2.8.

For definition of building use groups, see http://www.mass.gov/bbrs/780CMR_Ch03.pdf.

Slabs Below Grade

The entire area of a floor slab, which is below grade and is in contact with the ground shall be insulated with a minimum of R-5 rigid insulation in the following buildings: buildings of use group E, including daycare; buildings of use group R-1, R-2, I-1, and I-2 and; college and university buildings of B and A use groups.

Source: Massachusetts Building Code 780 CMR 1304.7 and 1304.8

For definition of building use groups, see www.mass.gov/bbrs/780CMR_Ch03.pdf.

Lighting

Uniform Reduction: Each perimeter office space enclosed shall have a manual control to allow the occupant to uniformly reduce the connected lighting load by at least 50%.

Exception: Spaces with automatic daylighting controls.

Source: Massachusetts Building Code 780 CMR 1302.8.3

Ventilation Controls for High-Occupancy Areas

Systems with design outside air capacities greater than 3000 cfm serving areas having an average design occupancy density exceeding 100 people per 1000 ft^2 shall include means to automatically reduce outside air intake below design rates when spaces are partially occupied. Ventilation controls shall be in compliance with the mechanical code listed in Appendix A. (ASHRAE 90.1—1999)

Exception: Fan systems with energy recovery.

Source: Massachusetts Building Code 780 CMR 1305.3.6.2

Variable Air Volume (VAV) Fan Control

Individual VAV fans with motors of 25 hp and larger shall have controls or devices that will result in fan motor demand of no more than 30% of design wattage at 50% of design air volume when static pressure set point equals 1/3 of the total design static pressure, based on manufacturer's certified fan data.

Static pressure sensors used to control variable air volume fans shall be placed in a position such that the controller set point is not able to exceed 1/3 the total design fan static pressure. If this results in the sensor being located downstream of splits in primary duct runs, multiple sensors shall be installed in each major duct.

For systems with direct digital control at the zone level, static pressure set points shall be capable of being reset based on the zone requiring the most pressure.

Source: Massachusetts Building Code 780 CMR 1305.3.10.1

Maximum Power Use (Pumps)

Individual pumps serving variable flow systems having pump motors greater than 50 hp shall include controls that are capable of limiting pump motor demand to no more than 30% of design power input at 50% of design water flow.

Source: Massachusetts Building Code 780 CMR 1305.3.5.5

Air Intake Locations and Outlets

Exhaust air and vent outlets shall be located no closer to outdoor air intakes than the minimum separation distance determined in accordance with Equation 2801.2.2.2:

Equation 2801.2.2.2:

$S = 0.09 * Q^{0.5} (D^{0.5} - V/400)$

S= Distance in feet between air intake and exhaust vent.

Q=Exhaust air volume, cfm.

D=Dilution Factor

V=Exhaust air discharge velocity, fpm.

See Massachusetts Building Code 780 CMR 2801.2.2.2 for more information on definitions of the above variables.

Appendix F

SAMPLES OF DOE 2.2 REPORTS

REPORT- BEPU Building Utility Performance WEATHER FILE- Boston MA TMY2

	LIGHTS	TASK LIGHTS	MISC EQUIP	SPACE HEATING	SPACE COOLING	HEAT REJECT	PUMPS & AUX	VENT FANS	REFRIG DISPLAY	HT PUMP SUPPLEM	DOMEST HOT WTR	EXT USAGE	TOTAL
EM1 ELECTRICITY													
KWH	1012189.	0.	124198.	0.	54361.	0.	72588.	617629.	0.	0.	0.	0.	1880962.
FM1 NATURAL-GAS													
THERM	0.	0.	0.	81372.	0.	0.	130.	0.	0.	0.	6048.	0.	87550.

TOTAL ELECTRICITY	1880962. KWH	9.302 KWH	/SQFT-YR GROSS-AREA	9.302 KWH	/SQFT-YR NET-AREA
TOTAL NATURAL-GAS	87550. THERM	0.433 THERM	/SQFT-YR GROSS-AREA	0.433 THERM	/SQFT-YR NET-AREA

PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE = 5.4
PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED = 0.0

NOTE: ENERGY IS APPORTIONED HOURLY TO ALL END-USE CATEGORIES.

REPORT- BEPS Building Energy Performance WEATHER FILE- Boston MA TMY2

	LIGHTS	TASK LIGHTS	MISC EQUIP	SPACE HEATING	SPACE COOLING	HEAT REJECT	PUMPS & AUX	VENT FANS	REFRIG DISPLAY	HT PUMP SUPPLEM	DOMEST HOT WTR	EXT USAGE	TOTAL
EM1 ELECTRICITY													
MBTU	3454.6	0.0	423.9	0.0	185.5	0.0	247.7	2107.9	0.0	0.0	0.0	0.0	6419.7
FM1 NATURAL-GAS													
MBTU	0.0	0.0	0.0	8137.2	0.0	0.0	13.0	0.0	0.0	0.0	604.8	0.0	8755.0
MBTU	3454.6	0.0	423.9	8137.2	185.5	0.0	260.8	2107.9	0.0	0.0	604.8	0.0	15174.7

TOTAL SITE ENERGY 15174.71 MBTU 75.0 KBTU/SQFT-YR GROSS-AREA 75.0 KBTU/SQFT-YR NET-AREA
TOTAL SOURCE ENERGY 28014.06 MBTU 138.5 KBTU/SQFT-YR GROSS-AREA 138.5 KBTU/SQFT-YR NET-AREA

PERCENT OF HOURS ANY SYSTEM ZONE OUTSIDE OF THROTTLING RANGE = 5.4
PERCENT OF HOURS ANY PLANT LOAD NOT SATISFIED = 0.0

NOTE: ENERGY IS APPORTIONED HOURLY TO ALL END-USE CATEGORIES.

REPORT- ES-D Energy Cost Summary WEATHER FILE- Boston MA TMY2

UTILITY-RATE	RESOURCE	METERS	METERED ENERGY UNITS/YR	TOTAL CHARGE ($)	VIRTUAL RATE ($/UNIT)	RATE USED ALL YEAR?
NStar G-3 (B3) block-2003	ELECTRICITY	EM1	1880962. KWH	208476.	0.1108	YES
NSTAR Gas Rate 22,27	NATURAL-GAS	FM1	87550. THERM	97398.	1.1125	YES
				305874.		

ENERGY COST/GROSS BLDG AREA: 1.51
ENERGY COST/NET BLDG AREA: 1.51

REPORT- ES-E Summary of Utility-Rate: NStar G-3 (B3) block-2003 WEATHER FILE- Boston MA TMY2

RESOURCE: ELECTRICITY DEMAND-INTERVAL 15 3413. BTU/KWH
BILLING-DAY: 31 RATE-LIMITATION: 0.0000
METERS: EM1
POWER-FACTOR: 0.80 EXCESS-KVAR-FRAC: 0.75 EXCESS-KVAR-CHG: 0.0000

RATE-QUALIFICATIONS		BLOCK-CHARGES	DEMAND-RATCHETS	MIN-MON-RATCHETS
MIN-ENERGY:	0.0	NStar summer peak 2003		
MAX-ENERGY:	0.0	NStar summer off-peak 2003		
MIN-DEMAND:	0.0	NStar winter peak 2003		
MAX-DEMAND:	0.0	NStar winter off-peak 2003		
QUALIFY-RATE:	ALL YEAR			
USE-MIN-QUAL:	NO			

MONTH	METERED ENERGY KWH	BILLING ENERGY KWH	METERED DEMAND KW	BILLING DEMAND KW	ENERGY CHARGE ($)	DEMAND CHARGE ($)	ENERGY CST ADJ ($)	TAXES ($)	SURCHRG ($)	FIXED CHARGE ($)	MINIMUM CHARGE ($)	VIRTUAL RATE ($/UNIT)	TOTAL CHARGE ($)
JAN	160649	160649	508.8	508.8	10639	4950	0	0	0	237	0	0.0985	15827
FEB	153765	153765	506.7	506.7	10196	4930	0	0	0	237	0	0.0999	15363
MAR	167748	167748	526.7	526.7	11126	5125	0	0	0	237	0	0.0983	16488
APR	160475	160475	553.0	553.0	10684	5381	0	0	0	237	0	0.1016	16301
MAY	175233	175233	576.8	576.8	11647	5612	0	0	0	237	0	0.0998	17496
JUN	176183	176183	601.5	601.5	12421	11832	0	0	0	237	0	0.1390	24489
JUL	115667	115667	363.9	363.9	8182	7159	0	0	0	237	0	0.1347	15578
AUG	111505	111505	350.5	350.5	7858	6894	0	0	0	237	0	0.1344	14989
SEP	172721	172721	577.6	577.6	12156	11362	0	0	0	237	0	0.1375	23755
OCT	177618	177618	537.9	537.9	11829	5233	0	0	0	237	0	0.0974	17300
NOV	154130	154130	517.9	517.9	10164	5039	0	0	0	237	0	0.1002	15440
DEC	155268	155268	505.1	505.1	10297	4915	0	0	0	237	0	0.0995	15449
TOTAL	1880962	1880962	601.5		127200	78431	0	0	0	2845		0.1108	208476

REPORT- ES-E Summary of Utility-Rate: NSTAR Gas Rate 22,27 WEATHER FILE- Boston MA TMY2

RESOURCE: NATURAL-GAS DEMAND-INTERVAL 60 100000. BTU/THERM
BILLING-DAY: 31 RATE-LIMITATION: 0.0000
METERS: FM1

RATE-QUALIFICATIONS | BLOCK-CHARGES | DEMAND-RATCHETS | MIN-MON-RATCHETS

MIN-ENERGY: 0.0
MAX-ENERGY: 0.0
MIN-DEMAND: 0.0
MAX-DEMAND: 0.0
QUALIFY-RATE: ALL YEAR
USE-MIN-QUAL: NO

MONTH	METERED ENERGY THERM	BILLING ENERGY THERM	METERED DEMAND THERM/HR	BILLING DEMAND THERM/HR	ENERGY CHARGE ($)	DEMAND CHARGE ($)	ENERGY CST ADJ ($)	TAXES ($)	SURCHRG ($)	FIXED CHARGE ($)	MINIMUM CHARGE ($)	VIRTUAL RATE ($/UNIT)	TOTAL CHARGE ($)
JAN	16936	16936	70.9	70.9	15177	0	3880	0	0	30	0	1.1270	19087
FEB	14336	14336	69.1	69.1	12847	0	3284	0	0	30	0	1.1273	16161
MAR	13046	13046	69.7	69.7	11690	0	2989	0	0	30	0	1.1275	14709
APR	8101	8101	55.4	55.4	7259	0	1856	0	0	30	0	1.1289	9145
MAY	3517	3517	47.7	47.7	3152	0	391	0	0	30	0	1.0160	3573
JUN	1313	1313	30.6	30.6	1177	0	146	0	0	30	0	1.0303	1353
JUL	1076	1076	28.4	28.4	964	0	120	0	0	30	0	1.0354	1114
AUG	1188	1188	28.5	28.5	1064	0	132	0	0	30	0	1.0328	1226
SEP	1378	1378	35.7	35.7	1235	0	153	0	0	30	0	1.0293	1419
OCT	4052	4052	51.3	51.3	3631	0	451	0	0	30	0	1.0148	4112
NOV	9844	9844	63.1	63.1	8821	0	2255	0	0	30	0	1.1283	11107
DEC	12763	12763	65.0	65.0	11437	0	2924	0	0	30	0	1.1276	14391
TOTAL	87550	87550	70.9		78454	0	18582	0	0	361		1.1125	97398

REPORT- LV-B **Summary of Spaces Occurring in the Project** WEATHER FILE- Boston MA TMY2

NUMBER OF SPACES 102 EXTERIOR 88 INTERIOR 14

SPACE	SPACE*FLOOR MULTIPLIER	SPACE TYPE	AZIM	LIGHTS (WATT / SQFT)	PEOPLE	EQUIP (WATT / SQFT)	INFILTRATION METHOD	ACH	AREA (SQFT)	VOLUME (CUFT)
Spaces on floor: Classroom Wing-1										
Soc.Stud.-south	1.0	EXT	-90.0	1.50	49.4	0.25	AIR-CHANGE	0.09	3704.5	33340.5
EL1 South Perim Spc (G.S2)	1.0	EXT	0.0	1.50	35.1	0.25	AIR-CHANGE	0.08	2632.5	23692.5
Soc.Stud.-north	1.0	EXT	180.0	1.50	59.6	0.25	AIR-CHANGE	0.07	4467.0	40203.0
English-south	1.0	EXT	-90.0	1.50	54.2	0.25	AIR-CHANGE	0.08	4066.5	36598.5
EL1 Core Spc (G.C5)	1.0	EXT	-90.0	1.50	4.9	0.25	AIR-CHANGE	0.01	2430.0	21870.0
English-north	1.0	EXT	180.0	1.50	89.1	0.25	AIR-CHANGE	0.08	6682.5	60142.5
Teach.Support-1	1.0	EXT	0.0	1.50	10.3	0.25	AIR-CHANGE	0.08	2052.0	18468.0
Bio/Physics	1.0	EXT	0.0	1.50	79.7	0.25	AIR-CHANGE	0.06	5980.0	53820.0
M/W-1a	1.0	INT	0.0	1.50	1.4	0.00	AIR-CHANGE	0.01	675.0	6075.0
M/W-1b	1.0	INT	90.0	1.50	1.5	0.00	AIR-CHANGE	0.01	756.0	6804.0
EL1 Core Spc (G.C11)	1.0	INT	0.0	1.50	3.9	0.25	AIR-CHANGE	0.01	1942.5	17482.5
EL1 SSE Perim Plnm (G.SSE12)	1.0	EXT	-90.0	0.00	0.0	0.00	AIR-CHANGE	0.09	3704.5	14818.0
EL1 South Perim Plnm (G.S13)	1.0	EXT	0.0	0.00	0.0	0.00	AIR-CHANGE	0.08	2632.5	10530.0
EL1 North Perim Plnm (G.N14)	1.0	EXT	180.0	0.00	0.0	0.00	AIR-CHANGE	0.07	4467.0	17868.0
EL1 South Perim Plnm (G.S15)	1.0	EXT	-90.0	0.00	0.0	0.00	AIR-CHANGE	0.08	4066.5	16266.0
EL1 Core Plnm (G.C16)	1.0	EXT	-90.0	0.00	0.0	0.00	AIR-CHANGE	0.02	2430.0	9720.0
EL1 North Perim Plnm (G.N17)	1.0	EXT	180.0	0.00	0.0	0.00	AIR-CHANGE	0.08	6682.5	26730.0
EL1 West Perim Plnm (G.W18)	1.0	EXT	0.0	0.00	0.0	0.00	AIR-CHANGE	0.08	2052.0	8208.0
EL1 East Perim Plnm (G.E19)	1.0	EXT	0.0	0.00	0.0	0.00	AIR-CHANGE	0.06	5980.0	23920.0
EL1 Core Plnm (G.C20)	1.0	INT	0.0	0.00	0.0	0.00	AIR-CHANGE	0.02	675.0	2700.0
EL1 Core Plnm (G.C21)	1.0	INT	90.0	0.00	0.0	0.00	AIR-CHANGE	0.02	756.0	3024.0
EL1 Core Plnm (G.C22)	1.0	INT	0.0	0.00	0.0	0.00	AIR-CHANGE	0.02	1942.5	7770.0
Spaces on floor: Classroom Wing-2										
Wrld.Lang.-south	1.0	EXT	-90.0	1.50	49.4	0.25	AIR-CHANGE	0.09	3704.5	33340.5
EL1 South Perim Spc (T.S24)	1.0	EXT	0.0	1.50	35.1	0.25	AIR-CHANGE	0.08	2632.5	23692.5
Wrld.Lang.-north	1.0	EXT	180.0	1.50	59.6	0.25	AIR-CHANGE	0.07	4467.0	40203.0
Math-south	1.0	EXT	-90.0	1.50	54.2	0.25	AIR-CHANGE	0.08	4066.5	36598.5
EL1 Core Spc (T.C27)	1.0	EXT	-90.0	1.50	2.4	0.25	AIR-CHANGE	0.01	2430.0	21870.0
Math-north	1.0	EXT	180.0	1.50	89.1	0.25	AIR-CHANGE	0.08	6682.5	60142.5
Teachr Support-2	1.0	EXT	0.0	1.50	10.3	0.25	AIR-CHANGE	0.08	2052.0	18468.0
Science	1.0	EXT	0.0	1.50	79.7	0.25	AIR-CHANGE	0.06	5980.0	53820.0
M/W-2a	1.0	INT	0.0	1.50	1.4	0.00	AIR-CHANGE	0.01	675.0	6075.0
M/W-2b	1.0	INT	90.0	1.50	1.5	0.00	AIR-CHANGE	0.01	756.0	6804.0
EL1 Core Spc (T.C33)	1.0	INT	0.0	1.50	3.9	0.25	AIR-CHANGE	0.01	1942.5	17482.5
EL1 SSE Perim Plnm (T.SSE34)	1.0	EXT	-90.0	0.00	0.0	0.00	AIR-CHANGE	0.09	3704.5	14818.0
EL1 South Perim Plnm (T.S35)	1.0	EXT	0.0	0.00	0.0	0.00	AIR-CHANGE	0.08	2632.5	10530.0

EL1 North Perim Plnm (T.N36)	1.0	EXT	180.0	0.00	0.0	0.00	AIR-CHANGE	0.07	4467.0	17868.0
EL1 South Perim Plnm (T.S37)	1.0	EXT	-90.0	0.00	0.0	0.00	AIR-CHANGE	0.08	4066.5	16266.0
EL1 Core Plnm (T.C38)	1.0	EXT	-90.0	0.00	0.0	0.00	AIR-CHANGE	0.02	2430.0	9720.0
EL1 North Perim Plnm (T.N39)	1.0	EXT	180.0	0.00	0.0	0.00	AIR-CHANGE	0.08	6682.5	26730.0
EL1 West Perim Plnm (T.W40)	1.0	EXT	0.0	0.00	0.0	0.00	AIR-CHANGE	0.08	2052.0	8208.0
EL1 East Perim Plnm (T.E41)	1.0	EXT	0.0	0.00	0.0	0.00	AIR-CHANGE	0.06	5980.0	23920.0

REPORT- LV-B Summary of Spaces Occurring in the Project WEATHER FILE- Boston MA TMY2

(CONTINUED)

EL1 Core Plnm (T.C42)	1.0	EXT	0.0	0.00	0.0	0.00	AIR-CHANGE	0.02	675.0	2700.0
EL1 Core Plnm (T.C43)	1.0	EXT	90.0	0.00	0.0	0.00	AIR-CHANGE	0.02	756.0	3024.0
EL1 Core Plnm (T.C44)	1.0	EXT	0.0	0.00	0.0	0.00	AIR-CHANGE	0.02	1942.5	7770.0
Spaces on floor: Gym Flr										
Gym	1.0	EXT	-90.0	1.50	369.7	0.10	AIR-CHANGE	0.00	18483.0	499041.0
Locker Rm-Girls	1.0	EXT	0.0	1.50	43.2	0.10	AIR-CHANGE	0.10	2160.0	19440.0
Fitness Center	1.0	EXT	0.0	1.50	51.8	0.10	AIR-CHANGE	0.05	2592.0	23328.0
Locker Rm-Boys	1.0	EXT	-90.0	1.50	51.8	0.10	AIR-CHANGE	0.09	2592.0	23328.0
Gym Storage	1.0	EXT	0.0	1.50	0.0	0.10	AIR-CHANGE	0.10	3022.5	27202.5
Gym Corridor	1.0	EXT	0.0	1.50	5.0	0.00	AIR-CHANGE	0.04	2511.0	22599.0
EL2 SW Perim Plnm (G.SW8)	1.0	EXT	0.0	0.00	0.0	0.00	AIR-CHANGE	0.10	2160.0	8640.0
EL2 South Perim Plnm (G.S9)	1.0	EXT	0.0	0.00	0.0	0.00	AIR-CHANGE	0.05	2592.0	10368.0
EL2 SE Perim Plnm (G.SE10)	1.0	EXT	-90.0	0.00	0.0	0.00	AIR-CHANGE	0.09	2592.0	10368.0
EL2 East Perim Plnm (G.E11)	1.0	EXT	0.0	0.00	0.0	0.00	AIR-CHANGE	0.10	3022.5	12090.0
EL2 South Perim Plnm (G.S12)	1.0	EXT	0.0	0.00	0.0	0.00	AIR-CHANGE	0.04	2511.0	10044.0
Spaces on floor: Cafeteria Floor										
Teacher Dining	1.0	EXT	0.0	1.50	49.0	0.00	AIR-CHANGE	0.17	980.0	8820.0
Kitchen	1.0	EXT	0.0	1.50	17.0	0.50	AIR-CHANGE	0.08	3403.8	30634.2
Cafeteria-Per.	1.0	EXT	90.0	1.50	343.1	0.00	AIR-CHANGE	0.12	6862.2	101560.6
Gen Stor/Maint	1.0	EXT	90.0	1.50	5.7	0.23	AIR-CHANGE	0.07	4295.3	38657.3
EL3 SSW Perim Plnm (T.SSW16)	1.0	EXT	0.0	0.00	0.0	0.00	AIR-CHANGE	0.17	980.0	3920.0
EL3 NW Perim Plnm (T.NW17)	1.0	EXT	0.0	0.00	0.0	0.00	AIR-CHANGE	0.08	3403.8	13615.2
EL3 Core Plnm (T.C20)	1.0	EXT	90.0	0.00	0.0	0.00	AIR-CHANGE	0.02	4295.3	17181.0
Lobby	1.0	EXT	0.0	1.50	37.0	0.00	AIR-CHANGE	0.03	1849.8	49943.3
Spaces on floor: Auditorium Floor										
Drame/Stagecraft	1.0	EXT	0.0	1.50	35.0	0.25	AIR-CHANGE	0.08	2624.0	26240.0
Band	1.0	EXT	0.0	1.50	22.2	0.25	AIR-CHANGE	0.05	1664.0	23296.0
Stage W	1.0	EXT	0.0	1.50	34.3	0.00	AIR-CHANGE	0.05	2573.0	36022.0
Auditorium W	1.0	EXT	0.0	1.50	269.8	0.00	AIR-CHANGE	0.05	5395.0	75530.0
Stage S	1.0	EXT	0.0	1.50	34.3	0.00	AIR-CHANGE	0.05	2573.0	36022.0
Auditorium S	1.0	EXT	0.0	1.50	269.8	0.00	AIR-CHANGE	0.05	5395.0	75530.0
Aud-Lckr/stor	1.0	INT	0.0	1.50	23.7	0.00	AIR-CHANGE	0.06	1776.0	17760.0
Aud corridor	1.0	EXT	0.0	1.50	10.4	0.00	AIR-CHANGE	0.08	5202.0	52020.0
Choral	1.0	EXT	0.0	1.50	22.2	0.25	AIR-CHANGE	0.05	1664.0	23296.0
Music office	1.0	EXT	0.0	1.50	1.5	0.75	AIR-CHANGE	0.05	228.0	3192.0
Chor/Band Stor	1.0	EXT	0.0	1.50	0.0	0.25	AIR-CHANGE	0.05	360.0	5040.0
Midi Lab	1.0	EXT	0.0	1.50	6.2	0.25	AIR-CHANGE	0.05	468.0	6552.0
Practice rms	1.0	EXT	0.0	1.50	12.2	0.25	AIR-CHANGE	0.08	913.0	9130.0
LOBBY 2	1.0	EXT	-90.0	1.50	15.6	0.00	AIR-CHANGE	0.03	780.8	21081.6
Spaces on floor: Library/Off wing										

Tech Ed	1.0	EXT	0.0	1.50	43.5	0.25	AIR-CHANGE	0.08	3264.0	32640.0
A/V	1.0	INT	0.0	1.50	14.4	2.00	AIR-CHANGE	0.08	1080.0	10800.0
Lib off/wrkrm	1.0	INT	0.0	1.50	4.8	0.75	AIR-CHANGE	0.08	960.0	9600.0
Lib-perim	1.0	EXT	0.0	1.50	11.6	0.25	AIR-CHANGE	0.08	1160.0	11600.0
North offices	1.0	EXT	0.0	1.50	9.8	0.75	AIR-CHANGE	0.08	1968.0	19680.0
West conf	1.0	EXT	0.0	1.50	9.0	0.25	AIR-CHANGE	0.08	448.0	4480.0
Library Int	1.0	INT	0.0	1.50	46.1	0.25	AIR-CHANGE	0.08	2303.0	23030.0
Office interior	1.0	EXT	0.0	1.50	25.7	0.75	AIR-CHANGE	0.08	5148.0	51480.0
Sick	1.0	EXT	0.0	1.50	5.4	0.25	AIR-CHANGE	0.08	1088.0	10880.0

REPORT- LV-B Summary of Spaces Occurring in the Project WEATHER FILE- Boston MA TMY2

(CONTINUED)

M/W-A	1.0	EXT	0.0	1.50	1.4	0.00	AIR-CHANGE	0.00	704.0	7040.0
Distance Learning	1.0	EXT	0.0	1.50	17.1	0.75	AIR-CHANGE	0.08	1280.0	12800.0
Corridor A	1.0	EXT	0.0	1.50	10.5	0.00	AIR-CHANGE	0.08	5256.0	52560.0
lib main hall	1.0	EXT	0.0	1.50	22.9	0.25	AIR-CHANGE	0.03	1715.0	44590.0
lib int 2	1.0	INT	0.0	1.50	9.1	0.25	AIR-CHANGE	0.08	686.0	6860.0
Spaces on floor: Lib/Off 2nd										
Art/ Fam Sci	1.0	EXT	0.0	1.50	65.6	0.25	AIR-CHANGE	0.08	4920.0	49200.0
Eng/Tchr Support	1.0	EXT	0.0	1.50	24.7	0.75	AIR-CHANGE	0.08	1856.0	18560.0
Comp Graph/Lab	1.0	EXT	0.0	1.50	35.2	2.00	AIR-CHANGE	0.08	2640.0	26400.0
Health Class	1.0	EXT	0.0	1.50	13.7	0.25	AIR-CHANGE	0.08	1024.0	10240.0
TV/Comp Rpr	1.0	EXT	0.0	1.50	23.0	2.00	AIR-CHANGE	0.08	1728.0	17280.0
Comp/ Lang Lab	1.0	EXT	0.0	1.50	36.8	2.00	AIR-CHANGE	0.08	2760.0	27600.0
Corridor A2	1.0	EXT	0.0	1.50	13.6	0.00	AIR-CHANGE	0.08	6784.0	67840.0
TEACHER SUPPORT 2	1.0	EXT	0.0	1.50	12.4	0.25	AIR-CHANGE	0.08	928.0	9280.0
Spaces on floor: AUDITORIUM 2ND FLOOR										
UPPER AUDITORIUM W	1.0	EXT	0.0	1.50	91.3	0.00	AIR-CHANGE	0.00	1826.0	42180.6
UPPER AUDITORIUM S	1.0	EXT	0.0	1.50	91.3	0.00	AIR-CHANGE	0.00	1826.0	42180.6
MECHANICAL RMS	1.0	EXT	0.0	1.50	0.0	0.00	AIR-CHANGE	0.00	3237.3	51797.1
BUILDING TOTALS					3145.0				300067.2	2922190.5

REPORT- LS-C BuiLding Peak Load Components WEATHER FILE- Boston MA TMY2

*** BUILDING ***

FLOOR AREA 202200 SQFT 18784 M2
VOLUME 2872389 CUFT 81346 M3

	COOLING LOAD		HEATING LOAD	
TIME	JUN 11 2PM		DEC 25 5AM	
DRY-BULB TEMP	89 F	32 C	6 F	-14 C
WET-BULB TEMP	70 F	21 C	4 F	-16 C
TOT HORIZONTAL SOLAR RAD	280 BTU/H.SQFT	882 W/M2	0 BTU/H.SQFT	0 W/M2
WINDSPEED AT SPACE	7.1 KTS	3.6 M/S	6.4 KTS	3.3 M/S
CLOUD AMOUNT 0(CLEAR)-10	1		3	

	SENSIBLE		LATENT		SENSIBLE	
	(KBTU/H)	(KW)	(KBTU/H)	(KW)	(KBTU/H)	(KW)
WALL CONDUCTION	38.645	11.323	0.000	0.000	-235.669	-69.051
ROOF CONDUCTION	162.999	47.759	0.000	0.000	-288.204	-84.444
WINDOW GLASS+FRM COND	120.195	35.217	0.000	0.000	-313.624	-91.892
WINDOW GLASS SOLAR	226.154	66.263	0.000	0.000	43.659	12.792
DOOR CONDUCTION	0.000	0.000	0.000	0.000	0.000	0.000
INTERNAL SURFACE COND	0.000	0.000	0.000	0.000	0.000	0.000
UNDERGROUND SURF COND	-103.497	-30.325	0.000	0.000	-134.283	-39.345
OCCUPANTS TO SPACE	376.932	110.441	525.285	153.908	12.290	3.601
LIGHT TO SPACE	821.212	240.615	0.000	0.000	75.244	22.046
EQUIPMENT TO SPACE	147.288	43.155	0.000	0.000	6.487	1.901
PROCESS TO SPACE	0.000	0.000	0.000	0.000	0.000	0.000
INFILTRATION	0.000	0.000	0.000	0.000	-122.178	-35.798
TOTAL	1789.927	524.449	525.285	153.908	-956.279	-280.190
TOTAL / AREA	0.009	0.028	0.003	0.008	-0.005	-0.015

TOTAL LOAD	2315.212	KBTU/H	678.357	KW	-956.279	KBTU/H	-280.190	KW
TOTAL LOAD / AREA	11.45	BTU/H.SQFT	36.112	W/M2	4.729	BTU/H.SQFT	14.916	W/M2

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*                                                          *
*  NOTE  1)THE ABOVE LOADS EXCLUDE OUTSIDE VENTILATION AIR *
*  ----    LOADS                                           *
*        2)TIMES GIVEN IN STANDARD TIME FOR THE LOCATION   *
*          IN CONSIDERATION                                *
*        3)THE ABOVE LOADS ARE CALCULATED ASSUMING A       *
*          CONSTANT INDOOR SPACE TEMPERATURE               *
*                                                          *
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REPORT- PS-C Equipment Loads and Energy Use WEATHER FILE- Boston MA TMY2

MON		COOL LOAD (MBTU) (KBTU/HR)	HEAT LOAD (MBTU) (KBTU/HR)	ELEC USE (KWH) (KW)	FUEL USE (MBTU) (KBTU/HR)		00 10	10 20	20 30	30 40	40 50	50 60	60 70	70 80	80 90	90 100	100 +	TOTAL RUN HOURS
Boiler 1																		
	SUM		-4786.0		7708.5	LOAD	1187	762	649	365	246	258	151	101	39	8	0	3766
	PEAK		-4966.6		6256.4	FUEL	561	876	634	563	396	269	216	158	72	21	0	3766
	MON/DAY		1/31		1/31													
Boiler 2																		
	SUM		-12.7		46.3	LOAD	70	1	0	0	0	0	0	0	0	0	0	71
	PEAK		-776.5		1975.5	FUEL	39	31	0	1	0	0	0	0	0	0	0	71
	MON/DAY		9/ 2		9/ 2													
Chiller 1																		
	SUM	633.8		54357.6		LOAD	1402	525	230	200	136	102	39	3	0	0	0	2637
	PEAK	1087.2		100.4		ELEC	1277	610	239	212	136	94	50	17	2	0	0	2637
	MON/DAY	6/ 3		6/ 3														
Domestic Water Heater																		
	SUM		-391.2		604.8	LOAD	6044	0	250	313	345	516	59	465	228	450	90	8760
	PEAK		-204.6		255.7	FUEL	4509	1535	131	235	404	456	226	439	184	641	0	8760
	MON/DAY		3/ 3		1/ 9													
CHWP-1																		
	SUM			19771.9		FLOW	0	0	0	0	0	0	0	0	0	0	2637	2637
	PEAK			7.5		RPM	0	0	0	0	0	0	0	0	0	0	2637	2637
	MON/DAY			3/ 3		ELEC	0	0	0	0	0	0	0	0	0	0	2637	2637
HWP-1																		
	SUM			50078.4		FLOW	0	0	0	4525	42	0	0	0	0	0	0	4567
	PEAK			12.4		RPM	0	0	0	0	0	0	0	0	0	0	4567	4567
	MON/DAY			1/31		ELEC	0	0	0	0	0	0	4567	0	0	0	0	4567